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A Generic Revision of the Limenitini of the World

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INTRODUCTION

A world revision of the Nymphalid tribe *Limenitini* is presented in the following pages. These conclusions have been based on a combination of the following characters: venation; male genitalia; and available knowledge of life-histories; supplemented by maculation, palpal characters, and distribution. Specimens have been available for study of most of the proposed generic names. However, no material of the genera *Pseudathyma* Staudinger, and *Euryphaedra* Staudinger, was studied; consequently no positive conclusions could be drawn as to their possible synonymy. The nomenclature is based on the rules of the International Code of Zoological Nomenclature.

Prior to 1892, the studies of this tribe were either limited to the descriptions of new species or genera, or short faunal accounts. No important systematic treatment was published from a world standpoint. Schatz (1892) was the first author to publish a comprehensive treatment of the world genera. His studies were based primarily on venation and palpal structures. Three of his tribes: "Neptis-Gruppe"; "Limenitis-Gruppe"; and "Euthalia-Gruppe" are considered as one in this paper. His classification, which was based primarily on venation, was found to be unnatural and has been altered considerably. Reuter (1896) published a classification of butterflies based on his studies of the palpi. He recognized two tribes, the *Limenitidi* and the *Neptidi*, subdividing the former into *Limenitini* and *Parthenini*. The Euthaliid complex was included under the *Limenitidi*, and the genera *Dynamine*, *Eunica*, *Cyrestis*, and *Stibochiona* were correctly rejected. His classification was found to be more natural than that of Schatz. Moore (1898-1900) surveyed the Limenitines of southeastern Asia, introducing many new generic names which were based primarily on slight differences in venation and maculation. He recognized two tribes: *Euthaliina* and *Limenitina*, including *Neptis* in the latter group. His tendency for erecting small genera was extremely unnatural and has led to confusion in the literature of that region. Aurivillius (1898) surveyed the African forms, and grouped them under two tribes: *Neptididi* and *Nymphalidi*. His work has been most helpful, although he based his classification on that of Schatz, contributing little in the way of new generic knowledge. Seitz (1924), Aurivillius (1925), Frühstorfer (1924, 1927), and Stichel (1909) have considered this tribe in reference to their restricted areas in the *Macrolepidoptera of the*

World. The disagreement among them on taxonomy has been considerable, although their classifications essentially followed the patterns of their predecessors. In no case was the tribe considered from a world standpoint by any one author. Consequently, there has been no world revision of this tribe since 1896, nor has there been any revision based on the combination of characters considered in this paper.

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TERMINOLOGY

The terminology used in this paper is one which is generally accepted in the literature on Lepidoptera. A brief summary is presented.

The venation is essentially that of Forbes (1923)—a modification of the Comstock-Needham system as applied to the Lepidoptera. The reader is referred to figure 1 for a summary of this system. Figures 2-5 show the variation of the branching of the subcostal and radial veins of the hindwings, along with the origin of the humeral. In *Parthenos* (figure 2), a subcostal cell is present on the secondaries, bounded by the bases of Sc, R, and R_1, with Rs arising from the end of this cell. In the more specialized Limenitines, the cell is open because of the loss of the base of R_1 (figure 3), although the former position of this vein is often indicated by slight protuberances on the subcostal and radial veins. The bases of Sc and R are approximate, and the humeral appears to originate from their point of contact. Two types of specialization develop from this pattern. In some species (figures 4), the bases of Sc and R fuse completely, and the humeral arises from their point of contact. In other specialized groups such as *Lebadea* and *Euthalia* (figures 5), Sc and R become strongly divergent and the humeral originates beyond their point of contact.

The terminology applied to the male genitalia is more or less standard among works on butterflies, and is explained in figure 32. Two terms are introduced in this paper: "Saccular lobe" which is characteristic of the genus *Limenitis;* and "Ventral lobe" a ventral protuberance of the valve.

In the larval stages, the terminology is simple. The numbers applied to the body segments are as follows: the segment immediately behind the head is "Number 1," and the remainder are numbered consecutively posteriorly. A longitudinal row of spines is present on either side of the midline, which have been named by Scudder (1889) "Laterodorsal" spines. The "Infrastigmatal" spines are ventral to the spiracles and extend longitudinally on both sides of the body. On the chrysalis, a "Dorsal lobe" may be present along the dorsal midline of the second abdominal segment, or a longer "Keel" in some genera. The head is terminated by two "Apical processes" or "Apical lobes."

SYSTEMATIC DISCUSSION OF THE LIMENITINI

Tribe LIMENITINI

1844. *Nymphalidae* Duponchel, Cat. Meth. des Lepid. d'Europe, pp. 8-11. (in part).
1969. *Limenitides* Butler, Cat. Diurn. Lepid. Desc. by Fabr. in the Col. of the Br. Mus., London, p. 57.
1875. *Archontes* Scudder, Bull. Buff. Soc. Nat. Hist., vol. 2, pp. 249-250.
1889. *Nymphalidi* Scudder, Butterflies of Eastern United States and Canada, vol. 1, p. 249.
1892. *Neptis-Gruppe* Schatz, Exotische Schmetterling, vol. 2, p 152.
1892. *Limenitis-Gruppe* Schatz, *ibid.*, p. 153.
1892. *Euthalien-Gruppe* Schatz, *ibid.*, p. 163.
1896. *Limenitidi* Reuter, Ueber die Palpen der Rhopalocera, Helsingfors, p. 498.
1896 *Neptidi* Reuter, *ibid.*, p. 510.
1898. *Euthalina* Moore, Lepidoptera Indica, vol. 3, p. 47.
1898. *Limenitina* Moore, *ibid.*, p. 141.
1898. *Neptididi* Aurivillius, Rhopalocera Aethiopica, p. 163.
1898. *Nymphalidi* Aurivillius, *ibid.*, p. 169.
1906. *Limenitidi* Stichel, in Seitz, Macrolepidoptera of the World, vol. 1, p. 173.
1906. *Euthaliinae* Stichel, *ibid.*, p. 188.
1924. *Limenitidi* Seitz, *ibid.*, vol. 5, p. 509.
1925. *Nymphalinae* Aurivillius, *ibid.*, vol. 13, p. 142.
1925. *Neptidinae* Aurivillius, *ibid.*, p. 198.
1927. *Neptididi* Frühstorfer, *ibid.*, vol. 9, p. 594.
1927. *Limenitidi* Frühstorfer, *ibid.*, p. 623.
1927. *Euthaliidi* Frühstorfer, *ibid.*, p. 649

This tribe is included in the *Rhopalocera* because of the clubbed antennae, and the loss of the frenulum. It also possesses the following characters of the Nymphalidae: the front legs are reduced in both sexes and lack tarsal claws; the radius has five distinct branches in the forewing; the wings are trifid, with M_2 arising near to R; the third anal vein is lost in the primaries; and two spines are present on the hind tibia. The *Limenitini* are included in the subfamily Nymphalinae because none of the veins of the primaries is swollen at the base; the third anal of the forewing is completely lost; and the larvae possess longitudinal rows of complex spines.

The genera of the *Limenitini* can be separated from all other Nymphalids by means of the following characters: the first anal vein is preserved as a short spur at the base of the cubitus in the primaries except in the genus *Neptis;* and the humeral is either bifurcate or roundly curved, if the latter, the humeral is directed distally and is never recurved basally. *Neptis* can be distinguished from other Nymphalids by a combination of the following: the cells of the fore and hindwings are open; and the bases of Sc and R are approximate or fused (figures 3 & 4) on the secondaries. In addition to these characters, R_3 always terminates at the apex of the primaries, with R_4 and R_5 meeting the outer margin. R_5 may arise before or after the apex of the cell. The upper discocellular of the forewing is either very short or lost. The cells of the wings may be open or closed. In the palpi, the basal segment is short, broad and curved; the middle segment is two and one-half to four times as long as the first, broad; the terminal segment is rarely longer, usually shorter than the first. The eyes may be naked or hairy, if the former however, minute micro-

scopic hairs are visible under high magnifications. The front legs of the female have spines on segments two to four.

The larval forms of the members of this tribe are characterized by four rows of spines, two of which are laterodorsal, and two infrastigmatal rows which extend from segments two to eleven. The first segment is devoid of prominent spines. Considerable modification of these exist and will be treated under the generic discussions. All of the known larvae, at least when young, seem to have a tendency to feed at the apex of a leaf, progressing basally leaving the midvein intact. Although this habit is characteristic of the Limenitines, it is not necessarily diagnostic. The chrysalids vary in shape and proportion. With few exceptions, they possess paired apical processes on the head. The cremaster is normal, and ornamental spines are lacking. A keel-like middorsal lobe or ridge is frequently present.

The adults of the species included in this tribe are usually found in wooded areas, preferring sunny spots. The habit of sitting on leaves of trees with their wings expanded, seems to be characteristic of the group. In addition, the majority of the species are attracted to fermenting fruits and bait.

The tribe *Limenitini* is world-wide in distribuion. In the Western Hemisphere, they range from southern Canada to southern Brazil, Bolivia and northern Argentina, also occurring on all of the larger Antillean Islands. They occur in Europe from southern Scandinavia to northern Italy, eastward through southern Russia and Siberia into China and India. The tribe is also found in Japan, Formosa, and the Philippines; and extends along the East Indies as far as the Solomon Islands and the northern parts of Australia. In Africa, it ranges from the Union of South Africa north to the Sahara Desert and southern Arabia.

Five genera have been included in the *Limenitini* by various authors, which are not considered in this paper. These are: *Eunica; Dynamine; Timetes; Cyrestis;* and *Chersonesia.* All five of these lack the first anal at the base of the cubitus of the forewing. All except *Eunica* have R_3 terminating before the apex of the wing along the costal margin; R_2 normally arising beyond the end of the cell; and the third segment of the palpi longer than the first. The subcostal vein of the primaries in *Eunica* is strongly swollen at the base. The larvae of *Cyrestis, Eunica, Chersonesia* and *Timetes* have a pair of well developed spines on the dorsal surface of the head. These characters are not typical of the *Limenitini* and will assign these genera to other tribes in the *Nymphalidae.*

KEY TO THE GENERA OF THE LIMENITINI

1. A small subcostal cell (figure 2) present on the hindwing; humeral vein bifurcate; cells of both wings closed ..... *Parthenos*
   No subcostal cell on the secondaries 2
2. First anal vein preserved as a spur at the base of the cubitus on the primaries 3
   First anal vein lost; cells of both wings open; the point of contact of veins M_3 and Cu_1 is distal to the bifurcation of M_1 and M_2 ..... *Neptis*
3. R_1 of the primaries coalesces with Sc for a short distance; saccus of male genitalia narrow, elongate, equal in length to the tegumen and the uncus combined; humeral vein short, straight, originating beyond junction of Sc and R ..... *Catuna*
   Not as above 4
4. Uncus of male genitalia bifurcate; gnathos weakly developed or lost ..... *Hamanumida*

Uncus of male genitalia not bifurcate 5
5. The bases of Sc and R widely divergent (figure 5) 6
The bases of Sc and R approximate or fused (figures 3 & 4) 8
6. Cell of primaries one-half the length of the wing, narrow; cells of both wings closed; humeral smoothly curved ..... *Lebadea*
Cell of primaries at most two-fifths the length of wing; cells may be closed or open; humeral may be evenly curved or bifurcate 7
7. R_3 of the primaries arises immediately beyond the cell; the cells of both wings closed; humeral simple, curved; hindwing with broad lobate anal angle; African ..... *Euryphaedra*
R_3 of the primaries arises more distally; Oriental and Australian ..... *Euthalia*
8. Cells of both wings open 9
Cells of at least the primaries closed 10
9. R_2 arises beyond cell of primaries ..... *Pseudathyma*
R_2 arises before cell of primaries ..... *Harma*
10. Cell of hind wing open 11
Cell of hind wing closed 13
11. Cell short and broad; pattern of lower surface usually cryptic; sexes dimorphic; usually a thin, dark, straight line extends across the middle of both wings on the lower surfaces ..... *Harma*
Cell elongate, narrow 12
12. Male genitalia with a saccular lobe; if no lobe present, a white band traverses the discal area of both wings ..... *Limenitis*
No saccular lobe, and no single white band traversing the wings; sexes dimorphic; lower surface partially cryptic ..... *Euthalia*
13. R_3 arises just beyond the cell ..... *Euphaedra*
R_3 arises at least halfway between the end of the cell and the apex of the primaries 14
14. R_2 arises beyond the cell ..... *Pseudacraea*
R_2 arises before the end of the cell 15
15. Cell of hindwing closed by a thin vein; cell short and broad; Sc, R_1, R_2 and R_3 parallel and closely approximate ..... *Harma*
Cell of hindwing closed by a well developed vein; Sc, R_1, R_2 and R_3 not closely parallel or approximate 16
16. Middle discocellular of forewing strongly concave basally; lower discocellular meets M_3 beyond that vein's intersection with Cu_1 ..... *Euthalia*
Middle discocellular of forewing tends to be straight; lower discocellular strongly concave, meeting M_3 at, or almost at that vein's point of contact with Cu_1 ..... *Pseudacraea*

Genus PARTHENOS Hübner

1819. *Parthenos* Hübner, Verz. Bek. Schmett., p. 38. Genotype: *Papilio sylvia* Cramer, 1776.

1832. *Minetra* Boisduval, *in* d'Urville, Voy. Astrolabe, Ent., I, p. 126. Genotype; *Papilio sylvia* Cramer, 1776.

Venation (figure 1).—Primaries: the subcostal vein is straight, meeting the costal margin two-thirds the distance from the base of the wing to the apex. R_1 branches from the radius at the middle of the cell, parallels Sc, and meets the costal margin before the apex. R_2 arises immediately before the end of the cell, is slightly bowed, and terminates almost at the apex of the wing. R_{3-5} originates from the end of the cell, with R_4 and R_5 branching halfway between the cell and the outer margin; R_3 originates slightly basad to this bifurcation and extends to the apex of the wing. The cell is closed; the upper discocellular

is lost; the middle straight; the lower, twice as long as the middle and strongly concave. The lower discocellular meets M_3 beyond its point of contact with Cu_1. M_1, M_2, Cu_1 and Cu_2 are all straight veins meeting the outer margin. M_3 is very strongly angulate. There is a short spur at the base of the cubitus which is the vestigial first anal vein. The second anal is slightly curved, runs parallel to the inner margin, meeting the outer margin slightly above the anal angle. Secondaries: the humeral vein originates from a small cell formed by the bases of the radial and subcostal veins. The humeral is bifurcate distally, the longer branch straight; the shorter, strongly curved and directed basally. The cell is closed by a well formed vein which meets M_3 at its point of contact with Cu_1.

Male genitalia (figure 33).—The uncus, tegumen and gnathos together, are small in comparison to the valve. The uncus is short, curved, with a small, pointed, apical hook. The gnathos is strongly elbowed medially, broad, and the two halves fused distally. The valve is complex, with both the costal and saccular folds well developed. The distal portion is ornate, with the saccular fold terminating in a serrate hook directed dorsally, and the dorsal portion of the valve terminating in a strongly developed, ventrally directed hook. The aedeagus is of the same length as the valve, narrow, pointed, and slightly curved.

The members of this genus have short heavy bodies, densely clothed with hairs. The eyes are naked. The antennae are half as long as the costal margin of the primaries, terminating in an elongate narrow club. The first segment of the palpus is short and strongly curved upward; the second segment is straight, twice as long as the first; the third segment is short, about two-thirds as long as the first segment, terminating in a point. The wings are large, with the primaries triangular, frequently falcate in the males. The costal margin is relatively straight, curving towards the apex which is sub-angular. The outer margin is slightly oblique and scalloped towards the anal angle. The hindwings are broad, subquadrate, with the outer margin strongly scalloped. In *P. tigrina aspila*, the wings are broader and less falcate.

In maculation, all of the species have a dark black-brown ground color on which is superimposed metallic green, blue, violet, or gold. Most species have white semihyaline markings in the intervenal spaces of the primaries which often enlarge to form an irregular discal band as in *Parthenos sylvia roepstorffi*, or may completely disappear as in *Parthenos tigrina aspila*. The dark bands traversing the cell of the primaries are strongly evident. On the lower surfaces, the hyaline markings still persist, although the iridescent colors are more widely distributed.

Early Stages.—These have been described by Moore (1898) with illustrations of the larvae and pupae of *Parthenos sylvia virens* Moore, and *Parthenos cyaneus* Moore. Ribbe (1895) described and illustrated the larva and chrysalis of *Parthenos tigrina aspila*. According to Frühstorfer (1927), all of the known larvae feed on various vines of the family *Cucurbitaceae* such as *Zehneria umbellata;* but Corbett says "Various species of *Vitaceae*."

Egg.—Unknown.

Larvae.—The head and first body segment are covered with short hairs. The second to eleventh body segments each bear laterodorsal spines. Those on the second segment are longest, the spines on the third, tenth and eleventh

segments shorter, while those on the fourth to ninth segments the shortest of all. These spines are covered with short bristles. A row of spines is present on each side of the body. These spines are much shorter than those of the laterodorsal row, with those on the second and third segments being forked, and the remainder simple. The anal segment is clothed with short bristles. In *Parthenos sylvia virens*, the head and legs are brown, the spines purplish, and the body green with a lateral yellow stripe. In *Parthenos cynaeus*, the head and legs are dark brown, the body longitudinally striped with yellow and brown, and transversely marked with rows of white spots. In *Parthenos tigrina aspila*, the larvae have longitudinal stripes similar to *cyaneus*, but lack the transverse markings.

Chrysalis.—The apical lobes typical of the *Limenitini* are present on the head. Other than this, it is relatively simple with a straight ventral surface, and a bowed, somewhat strongly keeled dorsal surface. The color is brown in *Parthenos sylvia virens* and *Parthenos cyaneus*, green in *Parthenos tigrina aspila*.

Habits.—The members of this genus are usually found in the lowlands, although in Burma, they have been recorded from altitudes of 3,000 to 5,000 feet. In India, they are primarily woodland forms, usually found in the jungles near water. They soar above the treetops with their wings held in a horizontal position, flapping them only rerely. Frühstorfer (1927) comments on their amazing ability to turn quickly in the air, and with strong wing beats, escape capture.

Distribution.—*Parthenos cyaneus* is restricted in distribution to Ceylon. *Parthenos tigrina* and its subspecies are limited to western New Guinea and the island of Waigiu. *Parthenos sylvia* with its numerous subspecies has the greatest distribution, occurring throughout India, Burma, southern China, the Mergui Peninsula, the Andamans and Nicobars, the Federated Malay States, throughout the Philippines from Luzon to Mindanao, and the Macromalayan Islands as far east as the Solomons. They are not found in the Micromalayan Islands nor Australia, which Frühstorfer (1927) attributes to the aridity of these islands.

The validity of the three species of *Parthenos* is open to question. Apparently, there is no overlapping of their ranges. *Parthenos cyaneus* has the same wingshape as *sylvia*, with a similar basic maculation. However, the larval differences would suggest that the species are valid. Genitalic differences occur throughout the various species and subspecies of this genus, and it is difficult to determine which character may be considered as being of specific diagnostic value. *P. tigrina* differs from the other species of *Parthenos* by the more rounded wingshape, the tendency towards the loss of white spots, and the loss of the blue or green color. The life history is apparently distinct. It is limited to western New Guinea and Waigiu, while subspecies of *P. sylvia* occur only in eastern New Guinea. If the species of *Parthenos* are valid, their distribution would indicate that the genus consists of only one large superspecies, with closely related species having evolved through the process of geographic subspeciation. This can best be determined by more data from New Guinea, and breeding experiments.

Genus HARMA Doubleday

1819. *Cymothoë* Hübner, Verz. Bek. Schmett., p. 39. Genotype: *Papilio amphicede* Cramer, 1779.
1848. *Harma* Doubleday, Gen. Diurn. Lepid., pl. 40. Genotype: *Harma theobene* Doubleday, 1850.
1850. *Pallene* Westwood, Gen. Diurn. Lepid., p. 289. Genotype: *Pallene eupithes* Westwood, 1850.
1861. *Amphidema* Felder, Nova Acta. Acad. Leop. Carol., vol. 28, p. 27. Genotype: *Diadema beckeri* Herrich-Schaeffer, 1852.
1879. *Paradiadema* Distant, Proc. Zool. Soc. London, p. 704. Genatype: *Paradiadema hora* Distant, 1879.
1891. *Euptera* Staudinger, Iris, vol. 4, p. 98. Genotype: *Euptera sirene* Staudinger, 1891.

The generic names which have been applied to this group are listed in the introduction. *Cymothoë* is the oldest name, and was first used by Hübner in 1819. In this genus, he included three species: *amphicede* Cramer; *althea* Cramer; and *aconthea* Cramer. Scudder (1875) correctly said that the name was preoccupied by *Cymothoa* Fabricius, 1793, and, in addition, Rafinesque had emended the Fabrician name to *Cymothoe* in 1814 (Precis Decouv. Somiol., p. 26). Consequently this name is not available for this genus of Limenitines. The next available generic name is *Harma* Doubleday, in which were originally included the following species: *theobene* Doubleday; *alcimeda* Godart; *fumana* Westwood; *althea* Cramer; *egesta* Cramer; *sangaris* Godart; *caenis* Drury; *jodutta* Westwood; and *eupithes* Doubleday. Scudder (1875) stated that the name was a homonym of *Arma* Hahn, 1833. However, no Article or Opinion of the International Code of Zoological Nomenclature specifically indicates that Scudder was correct. Consequently, *Harma* is to be retained as the generic name of this group. If, at some future time, the International Commission on Zoological Nomenclature should substantiate Scudder's view, the next available name for this genus would be *Amphidema* Felder. No genotype has been designated for *Harma* Doubleday, so I have selected *theobene* Doubleday, 1850 as type.

The name *Pallene* was used by Westwood in 1850 as a subgenus, including only the single species *eupithes*, which becomes the genotype by monotypy. However, this name is preoccupied by *Pallene* Meg., 1823; *Pallene* Johnst., 1837; and *Pallene* Less., 1837, and consequently is invalid. Felder proposed the name *Amphidema* in which he included only one species, *beckeri*, which is congeneric with *theobene*, thereby making *Amphidema* a synonym of *Harma*. Distant erected the genus *Paradiadema* in 1879, in which he included *hero* Distant, which also becomes a synonym of *Harma* because the types of these two genera are congeneric.

The genus *Euptera* has afforded some confusion. It was erected by Staudinger in 1891, and included three species: *sirene*, *telabontas;* and *hirundo*. Because of the lack of any previous designation, I have selected *sirene* Staudinger as the genotype. Aurivillius accepted this genus, although he recognized its close relationship to *Harma*. The separating character he emphasized was the open cell of the forewing which is closed in *Harma*. He also claimed that R_3 originates nearer to the apex of the cell than in *Harma* in which R_3 arises halfway between the cell and R_4 in the male. Also the humeral of the

hindwing of *Euptera* is supposed to arise just opposite the separation of Sc and R. The tendency for the lower discocellular to disappear in *Harma* has reached the point where it is only rarely present on the hindwing; while in the forewing, it is usually very weak. The open cell of the forewing in the species of *Euptera* is the culmination of this tendency. The majority of the white species of *Harma* such as *caenis, alcimeda* and the genotype *theobene* all have R_3 arising nearer the cell than to R_4, while in the other species such as *beckeri,* it shifts nearer to the outer margin. The description of the humeral vein in *Euptera* is equally applicable to species of *Harma* and is not diagnostic. The genitalia of *Euptera pluto* indicate that it belongs to *Harma,* along with the venational characters. Consequently, it is treated as a synonym in this paper.

Venation (figures 7 & 8).—Primaries: the cell is short and broad, from one-third to two-fifths the length of the wing. The subcostal vein is approximately three-fifths the length of the wing. R_1 originates three fourths of the distance from the base to the apex of the cell; R_2 arises between this point and the apex. R_{3-5} originates at the end of the cell, with R_4 and R_5 branching three-fourths of the way from the cell to the outer margin. In the males, R_3 originates at a point halfway between the cell apex and the branching of R_4 and R_5; in the females, it originates nearer to R_4. R_3 terminates at the apex of the wing. Sc, R_1, R_2 and R_3 are subparallel, and approximate. M_1 is more or less strongly curved; M_2 is not as strongly curved; while M_3 is obtusely angulate. Cu_1 and Cu_2 are almost straight. 1A is preserved as a short spur at the base of the cubitus; 2A is either straight or slightly undulate, usually parallel to the inner margin, and terminating at the inner angle. The middle discocellular is strongly concave basally. The lower discocellular is two and one-half times as long as the middle, and is also concave basally, meeting M_3 beyond that vein's point of contact with Cu_1. The lower discocellular is usually a rather thin vein, disappearing completely in some species such as *Harma pluto*. Secondaries: the smoothly curved humeral vein originates at the junction of Sc and R. The cell is slightly less than one-half as long as the length of the wing. It may be open or closed by a very thin vein which is slightly concave basally and usually meets M_3 at its point of contact with Cu_1.

Male Genitalia (figures 34, 35).—The uncus in most of the species is relatively short and broad, frequently strongly arched as in *Harma theobene*. In *Harma jodutta,* the uncus is straight and thin, similar in form to many of the species of *Limenitis*. In *Harma lucasi,* this structure is ornate, bearing a well formed dorsal spine near the terminus. The uncus of *Harma caenis* is slightly bifurcate at the tip, suggesting the possible origin of the complex bifurcate uncus of *Hamanumida*. In most species of *Harma,* the uncus is almost totally fused to the tegumen, with only a faint line visible at the suture point. The tegumen is heavily chitinized in all species, usually short and variable in shape. It may be strongly arched dorsally in some species as *Harma caenis,* while in others it is almost straight. The anterior margin of the tegumen is more or less aligned with the vinculum, a characteristic of this genus. The gnathos is boot-shaped, with the two component halves fusing at their apices. These gnathi vary from short, broad, heavily-chitinized

structures to relatively thin, narrow, elongate processes. The valves vary interspecifically, but as a rule are relatively long and slender. The costal and saccular folds are subparallel. Spines, hooks and hairs may occur along the sacculus or at the tip of the valves. This tendency for ornateness is best exemplified in *H. theobene*, in which the valve is strongly curved upwards, terminating in a blunt rounded point. The sacculus has a very heavily chitinized spine in the middle, and arising from the costa is a peculiar strap-like structure very characteristic of the species (figure 34). Excellent specific characters are found in the male genitalia. These center around the shape and comparative length of the uncus, tegumen and gnathos, and the shape and ornamentation of the valves.

The members of this genus have relatively short stout bodies, clothed with hairs which are dense and long on the dorsal surface of the abdomen and ventral surface of the thorax. The antennae are one-half as long as the primaries, or less, with a long tapering club which is fairly broad in some species. The first segment of the palpus is short, thick, rather strongly curved; the second segment is slightly narrower, straight except for a slight curve at the base, and two and one-half times as long as the basal segment; the terminal segment is two-thirds as long as the basal segment, narrow, and broadly pointed at the apex. The palpus is heavily clothed with hair which is longer on the ventral surface of the basal segment.

The wing expanse is variable among the species of *Harma*. In *H. alcimeda*, the length of the forewing (measured from base to apex) is only 23 mms. in the male. The length of the primaries of a female of *H. beckeri* is 48 mms. The shape of the wings varies with the species and sex. In the primaries of *H. alcimeda*, the costal margin is strongly arched; the outer margin is concave, with the apical portion lobate; the inner angle is 90°; the inner margin is straight. On the secondaries, the costal margin is slightly curved; the outer margin is somewhat produced between veins M_1 and M_2, and the anal angle is also produced into a very well developed lobe. The primaries of the females of this species are less falcate, and proportionally broader. The secondaries have the outer margin rounded and slightly crenulate; the anal angle is only weakly produced. In species such as *H. caenis* and *H. amphicede*, the primaries are only slightly concave on the outer margin; the anal angle is greater than 90°; the outer margin of the secondaries is smoothly rounded; and the anal angle only slightly produced. The margins tend to be less crenulate. In species such as *H. egesta*, the apex of the primaries is sharply angulate, while in most species it tends to be more rounded. *H. theobene* has very broad wings, with the costal margin of the primaries strongly bowed; the anal angle of the primaries is less than 90°, and the inner margin is concave. On the secondaries, M_3 is produced into a well developed lobe which is best developed in the female.

In color and maculation, this genus is very variable. However, two features seem to be present in all of the species. The first of these is a thin dark line which traverses the lower surfaces of both wings. On the primaries, it originates at the costal margin beyond the end of the cell, and meets the inner margin slightly beyond the middle. This line is angulate at vein M_1, but otherwise

straight, or almost so. On the secondaries, it originates slightly beyond the middle of the costal margin and continues in a straight course to the anal angle. In most species, this line is much darker and stands out in sharp contrast to the remainder of the wing. In *Harma beckeri,* it is of the same shade as the ground color, but its position is still discernable, particularly on the secondaries. The second character which is constant for the genus and occurs through most of the tribe, is the presence of spots in the cells on the lower surface. The first lies approximately in the middle of the cell, the second at the apex of the cell. Both of these are outlined by a thin border of a darker color, usually brown. These occur on both wings, but in some species as *H. beckeri,* the spot in the middle of the cell of the primaries becomes divided into four spots, all of which are outlined by a thin line, and all are in contact with one another. In *H. theobene,* these cellular spots tend to disappear. The color of the upper surface is variable. The males of many species such as *H. alcimeda* and *H. jodutta* are white, with black outer marginal bands; while the females are dark black-brown in the basal and limbal areas, with a white band traversing the wings in the discal areas. *H. sangaris* males are brilliant red on the upper surface, with a very thin margin of dark brown. The males of *H. beckeri* are bright tan in color, with the basal portions slightly lighter, and the limbal areas, particularly on the secondaries, a dark brown. The female of *H. beckeri* is dark black-brown with a complex arrangement of white spots on the primaries; the basal and limbal areas of the secondaries are white with some bluish iridescence, while the limbal area is black with two rows of white spots. There is also a large subanal discal patch of yellow-orange. Many species are relatively dark in color with a white, yellow, sometimes bluish band traversing the wings in the discal area. The lower surface of all of the species tends to be cryptic, usually a mottled mixture of browns and yellow; more rarely gray and white, or yellow and white. These contrast strongly with the more brilliant colors of the upper surfaces.

Early Stages.—The life history of *Harma amphicede* has been described by Aurivillius (1894). The following is based on his description and illustrations.

Egg.—Undescribed.

Larva.—The head is shiny black; the body a dusty yellow. The head has a bright midline extending to the clypeus. The head and body are clothed with short thin hair. The first and last segments of the body bear no complex spines; while segments two to eleven each carry two laterodorsal spines. These are shiny black, heavy, erect, expanding into a small knob at the apex. Those on the second, third, and eleventh segments are the longest, each having six to eight small spines along the sides, and crowned with four short spines. The dorsal spines on the fourth segment are shortest. The spines on the fourth to tenth segments have only three short lateral spines, with three additional apical ones. There is also an infrastigmatal row of spines on each side of the body, one to a segment. Those on the second and third body segments are shortest, and simple in structure. The remainder have a short stalk with a four pointed apex. The last abdominal segment is clothed with many simple spines, and bears a dorsal round black spot.

Pupa.—The head has two short, obtusely angulate terminal points. The remainder of the body is moderately rounded and smooth. A rather sharp longitudinal keel extends from the mesothorax to the eighth abdominal segment along the dorsum. The margins of the wings are also keeled dorsally. The cremaster is curved at right angles to the main axis of the body. Black markings occur along the dorsal margin of the wingcases, and at the base of the cremaster.

Larval specimens of *Harma alcimeda* received from Mr. Gowan C. Clark are similar to those of *H. amphicede*. The head is covered with pale hairs; the remainder of the body is also sparsely clothed with thin hair. Eight short thick spines are spaced on the dorsal surface of the head: two longitudinal rows of three on either side of the midline, with an additional lateral spine. The first body segment has four long dorsal hairs arising from tubercles. The laterodorsal rows of spines are similar to *amphicede*, although somewhat shorter and broader. The infrastigmatal rows, however, are better developed in *alcimeda*. Those on the second segment consist only of a group of two robust short spines; those on the third, of a group of three slightly longer ones. The infrastigmatal spines of the fourth to eleventh segments, however, are similar to and almost as long as those of the dorsum. The last body segment is slightly spinose on the dorsal surface, and is heavily clothed with short hair.

Habits.—Trimen (1887) has given some information on the habits of *Harma alcimeda*. It is a woodland species. The males fly rather high and out of reach, frequently sitting with their wings expanded. The females flit about nearer to the ground, where they are occasionally pursued by the opposite sex. Both sexes are attracted to moist areas such as damp mud and sand, where they alight to drink.

Distribution.—This genus is found in the wooded areas of central and southern Africa. They are relatively scarce on the east coast, and only one species, *H. alcimeda*, extends south into the northern portions of the Cape of Good Hope. This genus extends along the west coast as far north as Sierra Leone, occurring most abundantly in the Cameroons, the Congo, and Angola.

Genus PSEUDATHYMA Staudinger

1891. *Pseudathyma* Staudinger, Iris, vol. 4, p. 90. Genotype: *Pseudacraea sibyllina* Staudinger, 1890.

This genus was erected for the single species *sibyllina*, and Aurivillius (1898) has included three additional species. Because no specimens are available for study, the following is based on Aurivillius' description.

Venation.—Similar to *Harma* in that Sc, R_1, R_2 and R_3 in the forewing are subparallel, approximate, almost touching. R_2 has shifted in position so that it arises slightly beyond the end of the cell. The cell of the forewing is open. R_3 arises nearer to the cell than to the branching of R_4 and R_5. In the hindwing, the cell is open. The humeral arises opposite the point of bifurcation of Sc and R.

The costal margin of the primaries is slightly rounded, the outer margin only weakly concave. The outer margin of the secondaries is convex, slightly

crenulate; the anal lobe is lacking. In maculation, the members of this genus are mimics of the genus *Neptis*.

Life history.—Unknown.

Distribution.—Species of this genus occur from Sierra Leone, south along the west coast of Africa, to the Congo.

In venation, *Pseudathyma* is closely allied to *Harma*, and can only be separated from some species of that genus by the shifting of R_2 beyond the cell in the forewing, and the loss of the anal lobe on the hindwing. Many mimicking species of the *Limenitini* exhibit the tendency for R_2 to move beyond the cell in the primaries. This is particularly true when the wings are somewhat elongate, probably compensating for the increased stress on the wings. A number of species of *Harma* such as *elabontas* and *kinugnana* have a maculation which is already similar to *Neptis*. It is possible therefore, that the species of *Pseudathyma* represent the culmination of this tendency. If so, it is not at all unlikely that they belong to the genus *Harma*. This can only be determined by study of the male genitalia, and information on the life history.

Genus PSEUDACRAEA Westwood

1819. *Panopea* Hübner, Verz. Bek. Schmett., p. 39. Genotype: *Papilio semire* Cramer, 1780.

1850. *Pseudacraea* Westwood, Gen. Diurn. Lep., p. 281. Genotype: *Papilio hirce* Drury, 1782.

1861. *Panopaea* Felder, Nova Acta. Acad. Leop. Carol., vol. 28, p. 27. Genotype: *Papilio semire* Cramer, 1780.

1882. *Pseudoneptis* Snellen, Tijdschr. v. Ent., vol. 25, p. 221. Genotype: *Hesperia coenobita* Fabricius (*nec* Cramer), 1793.

1898. *Chloropoea Aurivillius*, Rhopalocera Aethiopica, p. 174. Genotype: *Papilio semire* Cramer, 1780.

Pseudacraea was erected by Westwood in 1850, and included three species: *hirce*, *euryta*, and *boisduvalii*. Of these three, Scudder (1875) selected *hirce* as the genotype. *Pseudacraea* is preceded by *Panopea* Hübner which included two species: *semire* and *lucretia*. Of these two, *semire* is selected as the genotype. Felder used the same generic name, but changed the spelling to *Panopaea*. Neither is available, however, because both are preoccupied by *Panopaea* Men., 1807 (Opinion 147 of the International Commission of Zoological Nomenclature). *Pseudoneptis* was erected by Snellen to include *coenobita*, a mimetic species which is considered as belonging to the genus *Pseudacraea* in this paper.

Venation (figures 9 & 10).—Primaries: the cell is less than half the length of the wing, although in *coenobita* it is approximately one-half. The area anterior to the radial stem is wider than in the African genera *Euryphene*, *Harma* and *Hamanumida*. The subcostal vein is slightly curved, terminating beyond the middle of the costal margin. R_1 and R_2 arise just before the end of the cell. R_3 originates from one-third to one-half the distance from the end of the cell to the apex of the wing, with R_4 and R_5 branching halfway between this point and the wing's apex. The radial branching varies in *coenobita* however: R_1 arises before the end of the cell, but R_2 to R_5 are evenly spaced

between the end of the cell and the apex of the wing. Sc, R_1 and R_2 meet the costal margin; R_3 terminates at the apex of the wing; and R_4 and R_5 meet the outer margin in all of the species of *Pseudacraea*. M_1 arises from the end of the cell. M_1 and M_2 are slightly curved; M_3 is broadly angulate towards the base. Cu_1 and Cu_2 are straight or slightly curved. 1A is preserved as a well developed spur at the base of the cubitus in all of the species except *coenobita*. In the latter, it is retained as a short triangular knob. The middle discocellular is straight; the lower discocellular is concave basally, twice as long as the middle, and meets M_3 beyond that vein's intersection with Cu_1. Secondaries: the bases of Sc and R are approximate and the humeral appears to arise from the point of bifurcation of these two veins. The cell is short and broad, closed by a well developed vein which terminates at the point of contact of M_3 and Cu_1.

Male genitalia (figures 36, 37).—The tegumen is broad, well developed, and curved on the dorsal surface. The uncus is as long or longer than the tegumen, only slightly curved, fairly broad and terminated by a small ventrally directed hook. The gnathos is well developed, approximately as long as the uncus, angulate, and fused distally. The vinculum is well developed, and the saccus is approximately as long as the tegumen. The valve is as long as the uncus and tegumen combined, fairly broad, usually smoothly rounded although frequently with small teeth at the apex. The saccular fold is entire. The costal fold often has a ventrally directed lobe at the base which is well developed in some species as *coenobita, dolomena* and *lucretia,* while reduced in species as *glaucina*. This lobular process is often ornamented along the margin with teeth. The aedeagus is usually as long as the tegumen and uncus combined, fairly broad, terminating in a point.

The antennae are from one-half to three-fifths the length of the wing, with a narrow elongate club. The eyes are naked. The palpi have a short curved basal segment; the middle segment is two to two and one half times as long as the basal segment, moderately curved; the apical segment is slightly shorter than the basal, rounded or broadly pointed at the tip. The shape of the wings varies with the species. The primaries always have a smoothly curved costal margin, with an evenly rounded apical angle. The outer margin may be weakly convex or fairly strongly concave. The latter is more characteristic of the genus resulting in a falcation of the primaries. The anal angle is usually weakly rounded, and the inner margin is straight. On the secondaries, the costal margin is slightly curved. The outer margin is strongly convex and crenulate. The anal angle is rounded, with the entire wing being subovate in shape. However in *glaucina*, the costal margin is almost straight; the anal angle is somewhat produced; the outer margin is only weakly convex, giving the wing a subtriangular outline. The females of the various species tend to have broader, less falcate wings than the males.

The maculation of this genus is exceedingly variable because all of the species have altered their patterns tremendously in mimicry of other genera. Probably the basic maculation was that of a blackish-brown ground color with a broad white transverse band on each wing. This is still preserved, although somewhat modified to mimic species of *Amauris*, in *lucretia*. The black

and white pattern is further modified in *coenobita* which mimics species of *Neptis*. This basic maculation has been lost in the majority of the species of *Pseudacraea* to be replaced by complex patterns of reds, browns and yellows in mimicry of the species of *Acraea* and *Planema*.

Life history.—The early stages of many of the species of *Pseudacraea* have been described by Aurivillius (1894), Carpenter (1912) and Fontaine (1911).

Egg.—In *Pseudacraea eurytus hobleyi*, the egg is spherical, somewhat flattened above, the surface sculptured with small hexagonal cells. These are usually attached to the extreme tip of a leaf.

Larva.—These vary among the species of *Pseudacraea*. In *coenobita*, the larva is dark brown with a reddish-brown head. The head is covered with very fine hairs, the remainder of the body is clothed with short stiff hairs. Two rows of laterodorsal spines extend from segments two to eleven. Those on segments two and three are slightly longer than the remaining. All of these spines are blue-black in color, rather heavy, erect, terminating in a small club. They are also sparsely clothed with short stiff bristles. An infrastigmal series of tubercles bearing short bristles extend from segments two to eleven along each side of the body. The larvae of some species are brilliantly colored as in *Pseudacraea lucretia tarquinia*. The body is green with a bright pink head, lateral line, and the first and last laterodorsal pairs of spines. *Pseudacraea boisduvali trimeni*, on the other hand, is dark brown in color with a general rugose appearance suggestive of a dead twig. The laterodorsal rows of spines are present in all of the species of *Pseudacraea*, although usually those on the second and eleventh body segments are the longest, while those on segments three to ten are shorter. The habits of these larvae are interesting. The earlier instars start feeding at the tips of leaves, eating everything but the main vein. When not feeding, they rest on these preserved veins of the leaves. The adult larvae usually rest on the stems of plants, and when disturbed, will raise their heads and posterior portions of their bodies, holding this position for long periods. The larvae of *P. lucretia tarquinia* feed on *Mimusops obovata* and two species of *Chrysophilum*. *P. eurytus imitator* and *P. boisduvali trimeni* feed on *Chrysophyllum natalense*.

Chrysalis.—In *coenobita*, the chrysalis is only slightly elongate, the head terminating in two blunt protuberances. The wing cases are expanded laterally. The body is strongly arched, with the ventral surface convex and the dorsal surface concave. The abdomen is keeled ventrally. In *tarquinia* and *trimeni*, the chrysalis is more elongate with a double long pointed projection on the head. The keeling of the dorsal surface of the abdomen is more pronounced, but still strongly arched as in *coenobita*. *P. eurytus imitator* has a well developed dorsal protuberance on the metathorax of the chrysalis. The chrysalids of *Pseudacraea* are usually suspended at the tip, or on the extreme margins of the leaves.

Habits.—Trimen (1887) gives an excellent account of the habits of the species found in southern Africa. The males of *P. lucretia tarquinia* are mimics of *Planema aganice*, and Trimen mentions mistaking them for the model in

flight. *Tarquinia* has the same slow floating flight of *aganice*, and like that species, settles at the very extremity of the leaf with its wings tightly closed. They hover about young trees at the edge of the woods, and accasionally settle on shady pathways in the forests. *P. lucretia imitator* is also a mimic of *Planema aganice* and flies with that species. Trimen quotes Bowker as stating that it is impossible to distinguish the difference between the mimic and its model in nature. However, once in the net, the soft body of *aganice* is immediately contrasted with the hard brittle body of *imitator*. As in the case of most Batesian species, they are relatively scarce in proportion to their models.

Distribution.—This genus is widely distributed through Africa, south of the Sahara Desert, ranging from Sierra Leone south to Angola on the west coast. It extends through the Congo area and Rhodesia; and occurs from Tanganyika south into Natal along the eastern coast. One species, *P. lucretia comorana* is found in the Comoro Islands off the east coast of Africa; and two species, *P. lucretia apaturoides* and *P. glaucina* are found on the island of Madagascar.

Little confusion has existed regarding the species included in this genus. On the basis of maculation and venation, they form a constant, easily definable group. However, the status of *Pseudoneptis* has been in confusion. Early authors such as Kirby (1871) had included its single species *coenobita* in *Catuna*. This probably was based on the relative similarity of their wingshape, and the fact that R_2 arises beyond the cell in the primaries of both species. However, on closer inspection, it is found that the venation of *coenobita* is almost identical to the species of *Pseudacraea* with the exception of the radial branching. However, the shifting of R_2 beyond the cell occurs over and over again among the Limenitines, and cannot be depended upon for a generic character. The wide area anterior to the cell of the primaries; the structure of the discocellulars of both wings; and the branching of the humeral, indicate the congeneric status of *Pseudoneptis* and *Pseudacraea*. The male genitalia bear this out further. Many of the species of *Pseudacraea* have a basal lobe of the costal fold of the valve which is also present in *coenobita* along with numerous other similarities in structure. The male genitalia of *Catuna* are relatively distinctive. Probably the most important character linking *coenobita* to *Pseudacraea* is the similarites of the early stages. The larvae of both have fairly long erect dorsal spines, while those of *Catuna* are still longer and horizontal in position similar to the Euthaliid line. The pupae of *Coenobita* and *Pseudacraea* are very strongly arched, while those of *Catuna* are not. For this reason, *coenobita* is linked with *Pseudacraea*, and considered as a member of that genus. Some authors might be led to consider it as a monotypical subgenus.

Genus LEBADEA Felder

1861. *Lebadea* Felder, Nova Acta. Acad. Leop. Carol., vol. 28, p. 28. Genotype: *Limenitis ismene* Doubleday and Hewitson, 1850.

Venation (figure 26).—Primaries: the subcostal vein is straight, parallel to the costal margin, and two-thirds as long as the wing. The cell is narrow, one-half the length of the wing. R_1 arises one-third before the end of the

cell, R_2 about one-sixth, with both veins intersecting the costal margin. R_{3-5} originates from the end of the cell with the fourth and fifth radials branching three-fifths the distance from the apex of the cell to the wing's apex. R_3 arises halfway between this point of bifurcation and the end of the cell, terminating at the apex of the wing. M_1 and M_2 are slightly bowed, and meet the outer margin. M_3 is obtusely angulate. Cu_1 and Cu_2 are straight. 2A is slightly undulate and parallel to the inner margin of the wing, meeting the outer margin slightly above the inner angle. 1A is preserved as a short spur at the base of the cubitus. The middle discocellular is short, almost straight; the lower discocellular is well developed, four and one-half times as long as the middle, more or less straight anteriorly, and inwardly concave posteriorly. It meets M_3 slightly beyond the point of bifurcation of M_3 and Cu_1. Secondaries: the humeral is simple and curved, originating distally to the point of bifurcation of Sc and R. The cell is short and broad, closed by a crossvein which meets the cubitus basal to the point of contact of M_3 and Cu_1.

Male genitalia (figure 38).—The dorsal surface of the tegumen is slightly curved. The uncus is slightly longer than the tegumen, narrow, evenly curved and terminating in a well developed, ventrally-turned hook. The gnathos is very narrow, delicate, angled near the apex, and the two halves fused at the tip. The vinculum and saccus are broad and well developed. The valve is simple, broad, about the same length as the tegumen and uncus combined. The costal and saccular folds are well developed, deep, and clothed with long hairs. The valve terminates in a short pointed process which is an extension of the costal fold. The aedeagus is as long as the valve, swollen towards the base, with the apex ending in an acute point.

The body of members of this genus is relatively short in comparison to the wings. The eyes are naked. The antennae are one-half the length of the primaries, relatively slender, terminating in a long taper club. The basal segment of the palpus is short and curved; the second segment is three times as long as the basal segment, curved basally and straight distally. The third palpal segment is slightly shorter than the basal, narrow and pointed. This genus is relatively homogeneous in size. The average length of the primaries in the males, measured from the base of the wing to the apex, is 27 mms.; in the females, 35 mms. Measurements of the primaries of a typical male of *Lebadea ismene martha* are: length of forewing from base to apex 27 mms.; from apex to inner angle, 21 mms.; and from base to inner angle, 18 mms. The primaries are falcate, with the costal margin slightly curved; the inner margin straight; the inner angle 90°; the outer margin straight from the inner angle to M_3, with a strong convex lobe along the apical portion. The secondaries of the male are subtriangular with the costal margin being slightly curved; the outer margin convex and crenulate, the inner angle smoothly rounded. In the female, the primaries are less falcate, the inner angle is more obtuse than in the male, and the outer margin is less concave and tends to be more crenulate. The secondaries of the female are slightly broader and more rounded than in the male.

The maculation of the various species of this genus is very similar and indicates their very close relationship. The ground color is essentially brown. A

narrow white band extends through the outer discal area, originating at the costal margin of the primaries, and meeting the middle of the inner margin. On the secondaries, the white band originates at the middle of the costal margin, and intersects the inner margin above the anal angle. On the primaries, this white band is bordered distally by a row of intracellular white lunules which are concave basally. This row occurs on the secondaries of some species. The apical portion of the primaries is suffused with white, and the limbal area of both wings is often suffused with orange-brown or tan. Transverse orange bars, bordered with narrow black lines, are found in the basal areas of both wings. A thin black submarginal band, somewhat crenulate, is found on both wings. The maculation of the lower surfaces reflects that of the upper, the white markings becoming somewhat more intensified, and the orange or tan overcast of the upper surface, more widespread.

Early stages.—Unknown.

Habits.—Primarily lowland forms, rarely occurring at elevations over 2,000 feet. They usually are found in open wooded areas, flying close to the ground and frequently taking refuge in low shrubs. Their flight is feeble, and frequently they alight on the leaves of trees and shrubs with their wings open.

Distribution.—Two species are recognized by Frühstorfer (1927). *Lebadea martha* with its subspecies, is found in the eastern Himalayas in Sikkim and Bhutan; eastward into Burma, and south into Siam, Indo China, and the Mergui Archipelago. *Lebadea alankara*, with its numerous subspecies, replaces *martha* in the Macromalayan region, occurring on the Malay Peninsula, Sumatra, Java, Bali, Nias, Borneo and Palawan. The eastward distribution is evidently governed by the revised Wallace's line.

The validity of these two species is questionable. They cannot be adequately separated on the basis of genitalia or venation, and the maculation is extremely similar, varying only in degree and intensity. In fact, material from the Malay Peninsula actually represents an intergradation between the two species. In no region do the two species occur side by side; instead, the distribution and variation are continuous. It is perhaps wiser therefore, to consider the genus *Lebadea* as being monotypic, with *martha* Fabricius, the oldest available name, being applied to the single species.

Genus LIMENITIS Fabricius

The first name applied to this genus was *Najas* Hübner, which was published in the Tentamen in 1806, and included only one species: *populi* Linnaeus. However, The International Commission on Zoological Nomenclature has declared the Tentamen invalid in Opinion 97, and the name *Najas* is therefore not available from that date. *Limenitis* Fabricus is the next name available for the genus.

Limenitis is a large, somewhat variable genus, although relatively homogeneous in most characters. The few morphological characters which do vary, appear not to be limited to any species groups (chart 1) such as *Athyma*,

CHART 1.—Variation in the subgenus *Limenitis*.

Species	Valve of Genitalia	Bases of Sc & R	Lower Discocellular	Lower Discocellular
populi	ornate	not fused	normal	concave
camilla	plain	not fused	normal	concave
sibylla	ornate	not fused	normal	concave
arthemis	ornate	fused	normal	concave
procris	ornate	not fused	distal	convex
lymire	ornate	not fused	normal	straight
libnites	plain	fused	distal	straight
sulpitia	plain	fused	normal	straight
pereus	plain	fused	distal	concave
punctata	ornate	not fused	normal	concave
recurva	ornate	fused	normal	concave

Limenitis, Basilarchia and *Moduza,* and are of minor significance. Consequently, it is almost impossible to subdivide the genus into natural subgenera. Any division would necessarily have to be based on one or two minor traits which would result in an artificial classification.

The South American species of this genus, however, seem to form an isolated unit which is relatively distinctive on the basis of color pattern and distribution. Probably a single species or group of closely related species, entered South America in preglacial times. Since then, they have exploded into numerous species and subspecies, all of which are basically similar in maculation and morphology. Because they form a large definable group, and because they do more or less represent an isolated unit, they are considered as constituting the subgenus *Adelpha* in this paper.

KEY TO THE SUBGENERA OF LIMENITIS

1. The second radial vein originates beyond the apex of the cell in the primaries 2
   The second radial vein originates at or before the apex of the cell in the primaries 3
2. A broad red, yellow, or white band is present on the primaries; the secondaries lack any light colored markings ..... *Adelpha* (in part)
   A continuous white band traverses both the front and hind wings ..... *Limenitis cottini*
3. The second cubital vein of the hindwing is produced into a fairly long, well developed tail; a white band is continuous across both wings ..... *Adelpha* (in part)
   The second cubital vein is not produced into a well developed tail 4
4. A broad submarginal or median yellow band or patch present on the primaries, not reaching the outer margin. This may be reduced to a subapical patch, or further reduced to a row of yellow spots, but in these cases, a continuous straight, white, extracellular band traverses the wing 5
   Not as above 6
5. A brick-red submarginal line distal to a yellow postmedian band is present on the primaries ..... *Limenitis zayla*
   The brick-red submarginal band is lacking; or if present, then the postmedial band is white or absent ..... *Adelpha* (in part)
6. Hindwings devoid of any contrasting maculation, or blue or blue-green iridescence. The apical area beyond the cell of the primaries, checkered with large white spots ..... *Adelpha demialba*
   Not as above ..... *Limenitis*

Subgenus LIMINITIS Fabricius

1806. *Najas* Hübner, Tentamen, p. 1. Genotype: *Papilio populi* Linnaeus, 1758.
1807. *Limenitis* Fabricius, Mag. f. Insektenk, Illiger, vol. 6, p. 281. Genotype: *Papilio populi* Linnaeus, 1758.
1819. *Callianira* Hübner, Verz. Bek. Schmett., p. 38. Genotype: *Callianira ephestiaena* Hübner, 1819.
1820. *Limonetes* Billberg, Enum. Ins., p. 78. Genotype: *Papilio populi* Linnaeus, 1758.
1828. *Nymphalus* Boitard, Manual Ent., vol. 2, p. 300. Genotype: *Papilio populi* Linnaeus, 1758.
1839. *Nympha* Krause, Fauna Thuringen, vol. 4, Schmett., p. 86. Genotype: *Papilio populi* Linnaeus, 1758.
1861. *Nymphalis* Felder, Nova Acta. Acad. Leop. Carol., vol. 28, p. 41. Genotype: *Papilio astyanax* Fabricius, 1775.
1864. *Procris* Herrich-Schaeffer, Prodrom. Syst. Lep., vol. 1, p. 23. Genotype: *Papilio procris* Cramer, 1777.
1857. *Pandita* Moore, Cat. Lep. Mus. E. India Co., vol. 1, p. 181. Genotype: *Pandita sinope* Moore, 1857.
1872. *Basilarchia* Scudder, Syst. Rev., p. 8. Genotype: *Papilio astyanax* Fabricius, 1775.
1881. *Moduza* Moore, Lepid. Ceylon, vol. 1, p. 47. Genotype: *Papilio procris* Cramer, 1777.
1898. *Balanga* Moore, Lepid. Indica, vol. 3, p. 146. Genotype: *Athyma kasa* Moore, 1858.
1898. *Bhagadatta* Moore, Lepid. Indica, vol. 3, p. 146. Genotype: *Lebadea austenia* Moore, 1872.
1898. *Chendrana* Moore, Lepid. Indica, vol. 3, p. 146. Genotype: *Athyma pravara* Moore, 1857.
1898. *Condochates* Moore, Lepid. Indica, vol. 3, p. 146. Genotype: *Limenitis opalina* Kollar, 1844.
1898. *Hypolimnesthes* Moore, Lepid. Indica, vol. 3, p. 146. Genotype: *Limenitis albomaculata* Leech, 1891.
1898. *Kalkasia* Moore, Lepid. Indica, vol. 3, p. 146. Genotype: *Limenitis alwina* Bremer & Gray, 1853.
1898. *Kironga* Moore, Lepid. Indica, vol. 3, p. 146. Genotype: *Athyma ranga* Moore, 1857.
1898. *Ladoga* Moore, Lepid. Indica, vol. 3, p. 146. Genotype: *Papilio camilla* Linnaeus, 1764.
1898. *Lamasia* Moore, Lepid. Indica, vol. 3, p. 146. Genotype: *Limenitis lyncides* Hewitson, 1859.
1898. *Litinga* Moore, Lepid. Indica, vol. 3, p. 146. Genotype: *Limenitis cottoni* Oberthur, 1884.
1898. *Parasarpa* Moore, Lepid. Indica, vol. 3, p. 146. Genotype: *Limenitis zayla* Doubleday & Hewitson, 1886.
1898. *Parathyma* Moore, Lepid. Indica, vol. 3, p. 146. Genotype: *Papilio sulpitia* Cramer, 1782.
1898. *Patsuia* Moore, Lepid. Indica, vol. 3, p. 146. Genotype: *Limenitis sinensium* Oberthur, 1876.
1898. *Pseudohypolimnas* Moore, Lepid. Indica, vol. 3, p. 146. Genotype: *Athyma punctata* Leech, 1890.
1898. *Putsuia* Moore, Lepid. Indica, vol. 3, p. 172. Genotype: *Limenitis sinensium* Oberthur, 1876.
1898. *Sabania* Moore, Lepid. Indica, vol. 3, p. 146. Genotype: *Athyma speciosa* Staudinger, 1889.
1898. *Sinimia* Moore, Lepid. Indica, vol. 3, p. 146. Genotype: *Limenitis ciocolatina* Poujade, 1886.
1898. *Sumalia* Moore, Lepid. Indica, vol. 3, p. 146. Genotype: *Limenitis daraxa* Doubleday & Hewitson, 1850.

1898. *Tacola* Moore, 1898. Lepid. Indica, vol. 3, p. 146. Genotype: *Limenitis larymna* Doubleday & Hewitson, 1850.
1898. *Tacorea* Moore, Lepid. Indica, vol. 3, p. 146. Genotype: *Athyma asura* Moore, 1857.
1898. *Tarattia* Moore, Lepid. Indica, vol. 3, p. 146. Genotype: *Limenitis lysanias* Hewitson, 1859.
1898. *Tharasia* Moore, Lepid. Indica, vol. 3, p. 146. Genotype: *Athyma jina* Moore, 1886.
1898. *Tatusia* Moore, Lepid. Indica, vol. 3, p. 146. Genotype: *Athyma kanwa* Moore, 1886.
1898. *Zabana* Moore, Lepid. Indica, vol. 3, p. 146. Genotype: *Athyma urvasi* Felder, 1860.
1898. *Zamboanga* Moore, Lepid. Indica, vol. 3, p. 146. Genotype: *Athyma gutama* Moore, 1858.

This group has usually been divided into three genera: *Limenitis* in the strict sense; *Pantoporia,* and *Basilarchia.* The name *Pantoporia* has been misused as was adequately explained by Hemming (1934), along with *Athyma,* which also has been applied to the same group of species. Both are synonyms of *Neptis,* and the next available name, therefore, is *Parathyma* Moore. This genus has been separated from *Limenities* on very weak grounds, primarily the fact that R_3 of the forewing arises beyond the midpoint between the cell and the apex of the wing. This character is variable throughout *Limenitis,* and lacks the constancy required of a diagnostic trait. Frühstorfer (1927) mentioned that the two genera cannot be distinguished on the basis of morphology, although he still continued to use them. Since they are identical to *Limenitis* in regard to venation, male genitalia, and life histories, the genus *Parathyma* is placed in synonymy.

The generic name *Basilarchia* Scudder, has been applied to North American members of this genus by most American authors. Neither Schatz (1892) nor Seitz (1924) have accepted the name, preferring to use *Limenitis.* The North American species are extremely similar to *populi,* the genotype of *Limenitis,* on the basis of morphology; even more so than the majority of the old world species. The larval forms are somewhat more specialized than in *populi* in having a further reduction of the laterodorsal spines, although the chrysalids are similar. Consequently, the name *Basilarchia* is treated as a synonym of *Limenitis* in this paper.

The species *elwesi* Oberthur, has been included in the genus *Limenitis* by most authors. Moore (1898), however, erected the monotypic genus *Chalinga* to include this species. *Elwesi* differs from *Limenitis* in having the cell of the hind wing closed by a well formed vein. R_2 arises beyond the end of the cell of the primaries. The humeral vein is not smoothly curved, but is strongly angulate. The apical segment of the palpus is extremely short, flattened, and broadly rounded at the tip. The antennae terminate in a very broad short club. The male genitalia show that this species bears no similarity to the *Limenitini.* The uncus is strongly bifurcate to the base, and the tegumen is reduced. The vinculum is broad, and the valves have a weakly developed costal fold, a well developed saccular fold, and are ornamented only with a few spines at the apex. It has been impossible to associate this species with any of the known tribes of the *Nymphalinae.* Knowledge of the life history

would be helpful in determining its true relationship. Tentatively it is placed in the genus *Chalinga* and will not be considered as belonging to the *Limenitini*.

Venation (figures 11 & 13-16).—Primaries: the subcostal vein is slightly curved, and is one-half to two-thirds the length of the costal margin. R_1 usually arises from the distal third of the cell, and R_2 between R_1 and the apex of the cell (figures 13 & 14). In *Limenitis camilla* and *sinensium*, R_2 arises from the apex of the cell (figure 15), while in *Limenitis cottini*, it arises a short distance beyond the cell (figure 16). R_3 usually arises halfway between the end of the cell and the apex of the wing, terminating at the apical angle. Sc, R_1, R_2 and R_3 are subparallel. The cell is one-half the length of the wing, sometimes shorter. The upper discocellular is usually preserved as a short straight vein; the middle discocellular is concave basally. The lower discocellular is always present, although varying in shape and position. In *L. linoides*, *L. perius* and *L. assura*, this vein shifts distally so that it intersects M_3 far beyond that vein's contact with Cu_1, and the middle discocellular is proportionally lengthened. This probably can be attributed to the attenuation of the wing in these species. The lower discocellular is often reduced in thickness and may be either concave, straight, or convex. Secondaries: the humeral is a smoothly curved vein. The bases of Sc and R are very closely approximate (figure 3) or completely fused (figure 4), with the humeral appearing to arise from their point of contact. The cell is usually short, suboval, and always open.

Male genitalia (figures 27-31, 39, 44-55).—These are relatively uniform throughout the genus, with the exception of the valves which exhibit a great deal of specific variation in shape and ornamentation. The uncus is fairly long, broad, slightly curved, with a short hook at the tip. The tegumen is slightly shorter than the uncus, curved dorsally, and well developed. The vinculum is of moderate width; the saccus is usually about as long as the tegumen. The gnathos is slightly curved, somewhat expanded and fused at the tip. The valve always bears a saccular lobe which is partially or completely covered with numerous short spines. This lobe is usually long, extending beyond the dorsal margin of the valve, although in a few species such as *L. camilla* (figure 41), it is shorter but still apparent. The costal and saccular folds are well developed; a ventral lobe is present in all species, although occasionally barely discernible. The valves are of medium length, although they may be attenuated in species such as *camilla*. Ornamentations in the form of spines or hooks are frequently present at the apex of the valves and provide good specific characters (figures 46-55).

The antennae are one-half to two-thirds the length of the primaries, with an elongate, narrow, terminal club. The eyes may be naked or more rarely, lightly clothed with hair. The first palpal segment is short and curved; the second is two and one-half to three times as long as the first, fairly strongly curved at the base, straight distally; the third segment is one-half to two-thirds as long as the first, narrow, usually rounded at the apex. The shape of the wings tends to be quite uniform. The costal margin is curved; the apical angle rounded; the outer margin is straight or weakly convex or concave; the

inner angle is usually approximately 90°; the inner margin is straight or slightly curved. The hind wings have a weakly curved, sometimes almost straight costal margin; the apex tends to be angulate; the outer margin is rounded although occasionally the anal angle is somewhat produced. The outer margins of both wings tend to be crenulate.

The maculation is essentially homogeneous throughout the group, with a brownish-black ground color, and a fairly broad white band composed of fused spots, traversing the middle of both wings. This maculation is modified in the case of mimics. One group of Indo-Australian species have a wing pattern suggestive of *Neptis*. Two other species: *punctata* and *albomaculata* are marked similarly to the males of *Hypolimnas*, In North America, one subspecies has lost the white band of the upper side completely, and mimics *Papilio philenor;* while other species mimic species of *Danaus* found in the same region. These mimics, however, can easily be assigned to *Limenitis* on the basis of genitalic structures. Sexual dimorphism does not occur among the species of this genus, both sexes exhibiting the mimicry pattern.

Life history.—The early stages of a large number of the species belonging to *Limenitis* are known. Some of these have been described in the works of Scudder (1889), Hofmann (1893), and Moore (1898-100). The variation among the larvae is marked, although following a definite plan of specialization. The pupal stages are relatively constant and tend to be diagnostic for the genus.

Egg.—Almost spherical, with hexagonal depressions bearing short spines at their intersections. These are oviposited singly, usually at the tip of a leaf.

Larvae.—These vary tremendously within the group. The primitive arrangement consists of fairly long, well developed, laterodorsal spines on segmens two to eleven, which are sparsely clothed with short bristles. The spines on segments 2, 3, 5, 10 and 11 are slightly longer than the remaining; while those on the fourth segment are extremely short. The infrastigmatal spines are short, occurring on segments two to eleven, and bears few bristles. This pattern of spines is present in *Limenitis opalina*. In *Limenitis sibylla,* a greater contrast of the laterodorsal spines is noticeable. Those on segments 2, 3, and 5 are very long and well developed; those on 10 and 11 are slightly shorter, while the spines on the remaining segments are extremely reduced in contrast. In *Limenitis camilla,* this specialization is still more noticeable. The spines on segments 2, 3, 5, 10, and 11 have become club-shaped, while the remaining are reduced to slightly raised tubercles bearing bristles. In *Limenitis procris,* the pattern of laterodorsal spines of *sibylla* is modified along a different line; those on segments two and three remaining long, while all of the other spines are shorter and subequal in size. In *Limenitis populi,* the structure of the laterodorsal spines of *camilla* has been retained; however, those on the second segment are very long, and those on segments 4, 6, 10, and 11 are somewhat shorter and broader; the remainder are reduced. In the North American species of *Limenitis,* we find the greatest specialization. The spines of the second segment are heavy and well developed. The remaining are reduced to tubercles, with those of segments 3, 5, 10 and 11 being somewhat larger.

Chrysalis.—These are relatively constant in shape throughout the genus, being fairly long, and somewhat rugose. Two structures are always present: a dorsal lobe on the second abdominal segment; and two tuberculate processes on the apex of the head which, in some species such as *Limenitis procris*, are greatly enlarged.

Habits.—The adults of this subgenus prefer open sunny areas in forests. Their flight is usually slow, although they are capable of very rapid flight when disturbed. They often sit on the leaves of trees and shrubs with their wings expanded.

Distribution.—This subgenus is widely distributed throughout the North Temperate Zone. In Europe, it occurs in England, and from the southern parts of Scandinavia and the Russian Baltic provinces, south into Sardinia, northern Italy, and Bulgaria. It extends east through southern Russia and Siberia into China, Korea, Japan and India. This subgenus also occurs on the Malay Peninsula and extends east along the islands to Java and the Celebes. They are common in the Philippines, Formosa, and Palawan, but have not been recorded from east of Weber's line. In North America, this subgenus ranges from southern Canada, through the United States, south into the provinces of Durango and Vera Cruz in Mexico.

Subgenus ADELPHA Hübner

1819. *Adelpha* Hübner, Verz. Bek. Schmett., p. 42. Genotype: *Papilio mesentina* Cramer, 1777.

1836. *Heterochroa* Boisduval, Roret's Suites a Buffon, Lepid., vol. 1, explic. pl. 8. Genotype: *Heterochroa serpa* Boisduval, 1836.

The name *Heterochroa* has frequently been used in a generic sense to include certain members of this subgenus. However, since these cannot be defined completely by any group of morphological characters, *Heterochroa* is considered as a synonym of *Adelpha*.

This subgenus is extremely similar to *Limenitis* in the restricted sense. However, it is treated as a unit in this paper because of its distinct maculation which tends to be constant throughout the group, with the exception of a few mimicking forms. In addition, their geographical isolation and their probable geological history, which will be discussed later, have led me to treat them as a distinct unit.

The venation of this subgenus is similar to *Limenitis*. However, in a few mimicking species such as *lara*, *melanthe*, and *mesentina*, R_2 arises beyond the cell. In *lara*, the lower discocellular of the forewing is reduced to a very weak vein. The venation of the secondaries is identical to that of *Limenitis*, although the bases of Sc and R are always fused. The antennae and palpi are similar to *Limenitis*. The eyes may or may not be obviously hairy.

The male genitalia of most species of *Adelpha* (figures 44 & 47-50) are the same as those of *Limenitis* proper. However, in a few species such as *serpa* and *bredowii*, the saccular lobe is completely lost. Short teeth are usually present along the apical margin of the valves, and are sometimes useful in species determination, although they do tend to vary intraspecifically.

The life histories are unmistakably referable to *Limenitis*, some larvae being specialized as in *arthemis* and *lorquini*, while others are much more generalized as in *Limenitis sibylla*. The chrysalids possess the dorsal lobes characteristic of the genus.

In habits, the adults of this subgenus are found in forested areas, usually flying in sunny open spots. Their flight is rather rapid, with a gliding motion. Frequently, they settle on leaves with their wings expanded.

In distribution, this subgenus ranges from Oregon, south along the west coast into Utah, Arizona, New Mexico and Texas. They occur throughout Mexico, Central America, into South America, where they extend into southern Brazil, Bolivia and northern Argentina. Species of *Adelpha* also are found in the larger Antilles.

Carpenter, in 1944, published an exhaustive treatment of the variation of "*Limenitis bredowii*." A few notes are added here to supplement his data. He proposed the interesting theory that *bredowii*, which he included in the genus *Limenitis* (corresponding to the subgenus *Limenitis* in this paper), is a mimic of *Adelpha*. However, he stated simultaneously that *Adelpha* exhibits few characters which are usually associated with models. He also commented on the fact that the male genitalia of *bredowii* are distinct and differ from all other North American *Limenitis*. The reason for this is relatively simple, for the male genitalia of this species agrees very favorably with a few Central and South American Adelphas which lack the saccular lobe. All members of the subgenus *Limenitis* possess these lobes. This group of Adelphas lacking the saccular lobes is abundant in Central America and southern Mexico, and they are further characterized by the white band of the primaries extending to the costal margin, while the orange band of the primaries is usually limited to a broad subapical patch (even absent in *gelania*). Carpenter has carefully pointed out that the maculation of the species of *Adelpha* and *bredowii* are very similar. On the basis of genitalia and maculation, the indications are that *bredowii* belongs to the subgenus *Adelpha*, not to *Limenitis*, and only represents a more northern extension of the range of that subgenus. If this is the case, the problem of mimicry is solved, for *bredowii* would then have the normal pattern of its subgenus.

Genus NEPTIS Fabricius

1807. *Neptis* Fabricius, Mag. f. Insektenk (Illiger), vol. 6, p. 282. Genotype: *Papilio aceris* Esper, 1783 (= *Papilio hylas* Linnaeus, 1758, ssp.).

1819. *Acca* Hübner, Verz. Bek. Schmett., p. 44. Genotype: *Papilio venilia* Linnaeus, 1758.

1819. *Pantoporia* Hübner, Verz. Bek. Schmett., p. 44. Genotype: *Papilio hordonia* Stoll, 1790.

1820. *Philonoma* Billberg, Enumeratio insectorum . . . , p. 78. Genotype: *Papilio aceris* Esper, 1783.

1850. *Athyma* Westwood, *in* Doubleday, Gen. Diurn. Lepid., p. 272. Genotype: *Papilio leucothoe* Linnaeus, 1764 (= *Papilio hylas* Linnaeus, 1758).

1861. *Phaedyma* Felder, Nova Acta. Akad. Leop. Carol., vol. 28, p. 31. Genotype: *Papilio heliodore* Cramer, 1779.

1881. *Rahinda* Moore, Lepid. Ceylon, vol. 1, p. 56. Genotype: *Papilio hordonia* Stoll, 1791.

1898. *Andasenodes* Moore, Lepid. Indica, vol. 3, p. 146. Genotype: *Neptis mimetica* Grose-Smith, 1895.

1898. *Andrapana* Moore, Lepid. Indica, vol. 3, p. 146. Genotype: *Papilio columella* Cramer, 1782.

1898. *Andrasenodes* Moore, Lepid. Indica, vol. 3, p. 248. Genotype: *Neptis mimetica* Grose-Smith, 1895.

1898. *Atharia* Moore, Lepid. Indica, vol. 3, p. 146. Genotype: *Limenitis consimilis* Boisduval, 1832.

1898. *Bacalora* Moore, Lepid. Indica, vol. 3, p. 146. Genotype: *Neptis pata* Moore, 1888.

1898. *Bimbisara* Moore, Lepid. Indica, vol. 3, p. 146. Genotype: *Limenitis sankara* Kollar, 1844.

1898. *Bisappa* Moore, Lepid. Indica, vol. 3, p. 146. Genotype: *Neptis neriphus* Hewitson, 1868.

1898. *Hamadryodes* Moore, Lepid. Indica, vol. 3, p. 146. Genotype: *Neptis ampliata* Butler, 1882.

1898. *Lasippa* Moore, Lepid. Indica, vol. 3, p. 146. Genotype: *Papilio heliodore* Fabricius, 1793.

1898. *Marosia* Moore, Lepid. Indica, vol. 3, p. 146. Genotype: *Neptis antara* Moore, 1858.

1898. *Palanda* Moore, Lepid. Indica, vol. 3, p. 146. Genotype: *Limenitis illegera* Eschscholtz, 1821.

1898. *Pandassana* Moore, Lepid. Indica, vol. 3, p. 146. Genotype: *Neptis fuliginosa* Moore, 1886.

1898. *Paraneptis* Moore, Lepid. Indica, vol. 3, p. 146. Genotype: *Papilio lucilla* Denis & Schieff., 1776.

1898. *Philonoma* Moore (*nec.* Billberg), Lepid. Indica, vol. 3, p. 226. Genotype: *Papilio agatha* Cramer, 1782.

1898. *Rasalia* Moore, Lepid. Indica, vol. 3, p. 146. Genotype: *Athyma gracilis* Kirsch, 1885.

1898. *Stabrobates* Moore, Lepid. Indica, vol. 3, p. 146. Genotype: *Neptis radha* Moore, 1857.

1898. *Tagatsia* Moore, Lepid. Indica, vol. 3, p. 146. Genotype: *Athyma dama* Moore, 1858.

The *Neptini* and *Limenitini* have been considered as separate groups by many authors, for example Schatz (1892), Aurivillius (1925) and Frühstorfer (1927). This separation of *Neptis* has been based on the following characters: the long third palpal segment; the loss of the first anal vein in the primaries; open cells in both wings; the frequent modification of the humeral which is either preserved as a normal curved vein, a short straight vein, or a bifurcate vein; and the modification of the laterodorsal rows of spines of the larvae to short wart-like protuberances. Of these characters, the only one that is constant and does not occur in the Limenitini, is the loss of the first anal vein. However, it is the author's opinion that the loss of this vein, which is already degenerate in the other Limenitines, represents a higher degree of specialization, for the cubitus in *Neptis* is still slightly swollen at the point of origin of the first anal The other venational characters, though constant in *Neptis*, occur occasionally throughout the *Limenitini* and cannot be accepted as diagnostic. The longer third palpal segment of *Neptis* is not sufficiently constant to be diagnostic. The modification of the dorsal spines of the larvae already occurs in the North American species of *Limenitis*. In fact, the Neptid larvae represent only a slightly higher degree of specialization of the *Limenitis* type. The chrysalis of *Neptis* also indicates the close relationship

of this genus to *Limenitis*, for species such as *Neptis hylas* retain the dorsal lobe characteristic of many *Limenitis*. For this reason, the *Neptini* of former authors is included in the *Limenitini*.

The genus *Neptis* has been divided into numerous genera and subgenera by many authors. Moore (1898-1900) carried this trend to its greatest extent, proposing 17 new genera based primarily on maculation and slight variation in venation. Frühstorfer (1927) divided *Neptis* into two genera: *Rahinda*, which he further divided into *Rahinda* and *Acca;* and *Neptis*, which he divided into *Neptis*, *Bimbisara* and *Phaedyma*. Aurivillius (1925), however, recognized only one genus. Neptis does tend to divide into two groups, but the characters used to distinguish them are only of subgeneric rank, because the entire genus is basically quite homogeneous. These two groups will be considered as subgenera in this paper.

KEY TO THE SUBGENERA OF NEPTIS

The apex of the valve in the male genitalia is smoothly rounded; the second radial vein of the primaries arises beyond the cell ..... Subgenus *Acca*

A spinose process, which is variable in structure, is present at the apex of the valve in the male genitalia; the second radial vein arises before the end of the cell in the primaries except in a few African species ..... Subgenus *Neptis*

Subgenus NEPTIS Fabricius

Venation (figure 17).—Primaries: the subcostal vein is shorter than in most Limenitines, rarely extending beyond the middle of the costal margin. R_1 and R_2 originate before the end of the cell, are subparallel to the subcostal vein, and intersect the costal margin. In a few African species such as *Neptis saclava*, R_2 arises shortly beyond the end of the cell. R_3 usually branches halfway between the end of the cell and the apex of the wing. R_4 and R_5 bifurcate near the outer margin. A short, straight upper discocellular separates the origins of R_{3-5} and M_1. M_1 and M_2 are slightly curved and meet the outer margin. M_3 and Cu_1 contact each other at a point further removed from the base of the wing than the middle discocellular. M_3 is broadly rounded towards its base. Cu_1 and Cu_2 are almost straight. The first anal vein is completely lost, although the base of the cubitus is often slightly swollen at its point of origin. The second anal is smoothly undulate and parallel to the inner margin. The cell is narrow, about two-fifths the length of the wing. The middle discocellular is concave basally. The lower discocellular has completely disappeared. Secondaries: the humeral is either straight, angulate, or bifurcate; it arises at the point of separation of Sc and R. $Sc-/-R_1$ is strongly curved and always meets the apex of the wing in the females. In the males of many species such as *hylas*, this vein is shorter, intersecting the costal margin, and Rs extends to the apical angle. M_3 and Cu_1 meet at a point further removed from the base, than the point of bifurcation of M_1 and M_2. M_3 is broadly curved at its base; Cu_1 and Cu_2 are almost straight. The cell is short and open. With the exception of variation of the humeral, and the few species having R_2 arising beyond the cell, the venation of this subgenus is very homogeneous.

Male genitalia (figure 40).—The tegumen is short and curved dorsally.

The uncus is narrow, equal in length to, or longer than the tegumen, often curved, and terminating in a small hook. The gnathos is either thin, or wide, slightly angulate, and fused at the apex. The vinculum is thin or heavy; the saccus is as long as, or shorter than the tegumen. The valve is somewhat elongate. The costal and saccular folds are well developed. The apex of the valve is terminated either by an upturned hook on the dorsal half, or a spine. In some African species (figure 43), this is reduced in size but still evident. The aedeagus is long, and may be either thin or heavy.

The antennae are usually one-half the length of the costal margin of the primaries, and are terminated by a long narrow club. The eyes are naked. The first segment of the palpi is short and curved; the second segment two to two and one-half times as long as the first, slightly curved towards the base; the third segment is usually as long as the first (longer than in most other Limenitines), narrow, straight, and bluntly pointed. The wings are elongate. In the primaries, the costal margin is slightly curved; the apical angle rounded; the outer margin straight or convex; the inner angle tends to be obtuse; the inner margin is somewhat sinuate. On the secondaries, the costal margin is strongly curved, particularly in the males; the apical angle is rounded; the outer margin convex; the inner angle rounded. The outer margins of both wings tend to be crenulate, particularly so in the African species.

In color and maculation, this group tends to be fairly uniform. The ground color of the upper surface is black; the lower surface may be suffused with tan, yellow, gray, or brick-red. The spots are white, yellow, gray, or pale green, and are repeated on the lower surface. A longitudinal streak is present in the cell of the primaries of the typical group, which may be broken into spots in some species. A series of white spots or a band extends from the costal margin to vein Cu_2, beyond the cell; and another from the middle of the inner margin to vein Cu_2. A single or double row of submarginal spots is present on both wings. On the secondaries, a narrow or broad band extends from the middle of the costal margin to the middle of the inner margin. Distal to this band, but parallel to it, is another row of spots which may be fused together. All of these light markings vary in development, either becoming broad, or tending to disappear entirely.

Life history.—The early stages of a number of species of *Neptis* have been described by Moore (1898); Frühstorfer (1927) and Hofmann (1893). The following is a compilation of the principal characters.

Eggs.—These are thimble shaped, marked with regular hexagonal pits, the outlines of which are covered with short dense bristles. They may be oviposited near the apex of the leaves, or on the lower surfaces.

Larvae.—These are of two general types, the variation being in the structure of the laterodorsal spines. The larvae of species such as *Neptis hylas varmona* and *Neptis lucilla* are very similar to the larvae of *Limenitis camilla*. The latero-dorsal rows of spines are reduced to short rounded

subequal lobes, bearing bristles, on body segments 2, 3, 5, and 11. In *L. camilla*, they are similar in structure, and occur on these same body segments, plus the tenth. The laterodorsal spines on the remaining segments are lost, along with the infrastigmatal spines. This pattern is more highly modified in species such as *Neptis jumbah*. The spines on the second body segment of this species are reduced in size; those on the third segment are elongate, pointed, and project forward and outward; the spines on the fifth segment are also reduced, directed slightly backward; the spines of the eleventh segment are almost as long as those on the third, pointed, and directed posteriorly. The head is usually covered with short bristles, and the body of larvae is clothed with short pubescent hairs.

Chrysalis.—Similar in structure to that of *Limenitis*. The dorsal lobe is well preserved in *Neptis hylas*. In the majority of species, however, it tends to be reduced or disappears. The head has two pointed apical projections.

Habits.—Frühstorfer (1927) states that species of *Neptis* have been recorded from altitudes as high as 10,000 feet in China, and in Sikkim reach altitudes of 12,000 feet. Few species are found flying in the woods, preferring open sunny spots where they are common members of the fauna. They are often attracted to flowers. Trimen (1887) mentions that the African species frequent wooded areas, fly rather slowly, often settling on the leaves of low trees. They also are attracted to blossoms.

Distribution.—This group is found throughout the warmer regions of the Old World, with the greatest variety of species occurring in southern China and India. They range as far north as Amur and Yesso; and extend into Europe through southern Russia and Roumania, as far west as southern Switzerland. They are found throughout the islands of Japan, Formosa, the Philippines, and the Macro — and Micromalayan Islands as far east as the Solomons. Species also occur in the northern areas of Australia. In Africa, this group ranges from the Sahara, south into Cape Colony, also occurring on Madagascar, Mauritius, and islands of the Comoro group.

Subgenus ACCA Hübner

In venation (figure 18), this subgenus is similar to *Neptis* in all respects except that the second radial vein of the primaries always arises beyond the cell. The valves of the male genitalia are smoothly rounded at the apex (figure 42), lacking any of the processes which are characteristic of *Neptis*. It is the combination of these characters which has led the author to consider this group as a subgenus. The basic color patterns of *Neptis* and *Acca* are the same, although all of the species of the latter have yellow markings with the exception of *venilia* in which the markings are white, outlined by blue in the male, a coloring which is unusual in *Neptis*.

The early stages of *Neptis* (*Acca*) *hordonia* have been described by Moore (1899). In general, the larva is similar to the more highly specialized *Neptis*. However, the laterodorsal spines are somewhat modified. The spines occur on body segments 2, 3, 5, and 11, and are all elongated

and pointed. The first two pairs are erect, while those on the fifth and eleventh segments are directed posteriorly. The dorsal lobe of the chrysalis has been lost.

Acca is not quite as widespread a group as *Neptis*. It is found throughout India, including Ceylon, and ranges north into southern China, and east into Burma and the Malay Peninsula, also occurring on the Andamans and Nicobars. This subgenus also flies on Formosa, the Philippine Islands and Palawan. It extends along the Macromalayan Islands as far east as Papua and the Bismarck Archipelago, also occurring in the northern coastal areas of Australia.

Genus CATUNA Kirby

1819. *Jaera* Hübner, Verz. Bek. Schmett., p. 38. Genotype: *Papilio crithea* Cramer, 1773.
1867. *Euomma* Felder, Reise Novara, p. 425. Genotype: *Euomma angustatum* Felder, 1867.
1871. *Catuna* Kirby, Syn. Cat., p. 238. Genotype: *Euomma angustatum* Felder, 1867.

The name *Catuna* was proposed by Kirby in 1871 to include four species: *crithea, angustatum, opis,* and *coenobita.* In 1873, the same author designated *angustatum* as the genotype. Both *Euomma* and *Jaera* are older names, but are invalid because they are preoccupied. *Jaera* was erected by Hübner in 1819 and contained three species: *opis, afer* and *crithea. Crithea* is selected as the genotype because of no previous designation. This name is a homonym of *Jaera* Leech, 1815. *Euomma* was erected by Felder in 1867, containing the single species *angustatum* which becomes the genotype by monotypy. However, this name is also preoccupied by *Euomma* Boh., 1858, and consequently is not available.

Venation (figure 19).—Primaries: the subcostal vein is straight, terminating slightly beyond the middle of the costal margin. R_1 arises before the apex of the cell, fuses for a short distance with the subcostal, and then meets the costal margin. R_2 originates beyond the cell, about one-third the distance beyond the end of the cell and the apex of the wing. This vein is short, almost straight, and meets the costal margin. R_3 arises halfway between the point of origin of R_2 and the branching of R_4 and R_5, terminating at the apex of the wing. R_4 and R_5 end at the outer margin. M_1 and M_2 are slightly curved, M_3 broadly angulate, all three veins meeting the outer margin. Cu_1 and Cu_2 are straight. The first anal is preserved as a short spur at the base of the cubitus; the second anal is undulate and subparallel to the inner margin. The cell is slightly less than one-half the length of the wing, and is of average width. The middle discocellular is slightly concave. The lower discocellular is twice the length of the middle, slightly concave, and meets M_3 beyond that vein's junction with Cu_1. Secondaries: the humeral is short, slightly rounded, and arises beyond the junction of Sc and R. The cell of the hindwing is open.

Male genitalia (figure 59)—The tegumen is short and broad, the dorsal surface straight. The uncus is slightly longer than the tegumen and strongly curved. The gnathos is well developed, weakly S-shaped, and fused at the apex. The saccus is narrow, equal in length to the tegumen and uncus

combined. The valves are broad, as long as the saccus, with well developed costal and saccular folds. The ventral lobe is well developed. The aedeagus is long, narrow, and delicate.

The antennae are three-fifths as long as the forewing, with a narrow elongate club. The eyes are naked. The basal segment of the palpus is short and curved; the second segment is two and one-half times as long as the first, with the proximal half slightly curved; the terminal segment is almost as long as the basal segment, narrow, and pointed at the tip. The wings are elongate. The costal margin of the primaries is arched; the outer margin convex; the anal angle rounded; and the inner margin somewhat sinuate. On the secondaries, the costal margin is almost straight, only slightly curved; the apex is strongly angulate; the outer margin is strongly convex and crenulate; the inner angle is rounded.

This genus is relatively constant in maculation, with only slight sexual dimorphism. The ground color of the upper surface is brown; with a complex arrangement of tan markings on the primaries. The secondaries are characterized by a yellowish band which extends from the apex of the wing where it is fairly broad, almost to the inner margin near the base of the wing where it tapers to a truncate point. Two narrow yellow bands, one a submarginal band and the other a discal band, roughly parallel the outer margin. On the lower surface, the ground color is yellow-tan. The dark maculation of the upper surface of the primaries is reflected on the lower surface, and the two transverse cellular spots are clearly evident. On the secondaries, a faint brown line marks the position of the submarginal and discal yellow lines of the upper surface, the remainder of the wings being homogeneous yellow-tan.

Life history.—The early stages of *Catuna oberthuri* were described by Aurivillius (1894), and serve as a basis for the following description.

Egg.—Unknown.

Larva.—The head is black, the body green. The laterodorsal rows of spines extend from segments two to eleven. The spines on segments two and three are slightly longer than the remaining, and terminate in long hair-like filaments. The laterodorsal spines are black, long, of even width throughout, and clothed with smaller spinules. They extend horizontally as in *Euthalia,* but lack the feathery character of the larval spines of that genus. Apparently, the infrastigmatal spines are absent. The body is sparsely clothed with short pubescent hairs.

Chrysalis.—Relatively short and broad, with a strongly arched ventral surface. The head has two short obtuse points at its apex. The color is green, with milk-white wingcases.

Distribution.—This genus ranges from Sierra Leone on the west coast of Africa, south to the Congo and Uganda, and east into Tanganyika.

Aurivillius (1925) listed four distinct species as belonging to this genus, three occurring in western Africa, and the fourth found in Tanganyika. Their similarity in maculation and morphology would indicate that these species have only recently evolved, and as such, might even be considered as

constituting one superspecies. Additional material and data on distribution would be needed to determine these relationships. The larval characters would place this genus along the Euthaliid stem, although the laterodorsal spines of the larvae have not as yet, developed the featherlife appearance of the higher genera. The morphological characters, particularly in venation, are sufficient to distinguish this genus from any of its near relatives.

Genus HAMANUMIDA Hübner

1819. *Hamanumida* Hübner, Verz. Bek. Schmett., p. 18. Genotype: *Papilio meleagris* Cramer, 1779 (= *Papilio daedalus* Fabricius, 1775).
1833. *Aterica* Boisduval, Ann. Mus. Hist. Nat., p. 195. Genotype: *Aterica rabena* Boisduval, 1833.
1861. *Canopus* Wallengren, *in* Felder, Nova Acta. Acad. Leop. Carol., vol. 28, p. 33. Genotype: *Papilio daedalis* Fabricius, 1775.
1888. *Cynandra* Schatz, Exot. Schmett., vol. 2, p. 161. Genotype: *Papilio afer* Drury, 1782.
1891. *Euryphura* Staudinger, Iris, vol. 4, p. 103. Genotype: *Euryphene plautilla* Hewitson, 1865.
1892. *Pseudargynnis* Karsch, Ent. Nachr., vol. 18, p. 173. Genotype: *Jaera duodecimpunctata* Snellen, 1872.
1893. *Diestogyna* Karsch, Berlin Ent. Zeitschrift, vol. 38, p. 181. Genotype: *Papilio veronica* Cramer, 1782.
1894. *Crenidominas* Karsch, Ent. Nachr., vol. 20, p. 258. Genotype: *Harma concordia* Hopffer, 1855.
1895. *Metacrenus* Butler, Proc. Zool. Soc. Lond., p. 259. Genotype *Crenis crawshayi* Butler, 1893.
1903. *Leucosticha* Rothschild & Jordan, Novit. Zool., vol. 10, p. 538. Genotype: *Papilio daedalus* Fabricius, 1775.

This genus is extremely variable in maculation and shape of wings. Many of the species are mimicking forms, and as such, differ markedly from the normal color pattern. This variation has led to the proposal of numerous genera based on these superficial characters. However, since these lack the support of constant morphological characters, they are treated in this paper as synonyms of one large genus.

The following genera have been accepted by many authors as being distinct: *Hamanumida; Aterica; Cynandra; Euryphura; Pseudargynnis; Diestogyna;* and *Crenidominas*. These are treated as one genus in this paper. The oldest available name is *Hamanumida*, the genotype of which has been designated by Scudder (1875) as *daedalus*. The use of this name has been previously limited to this one species by most authors.

Aterica was described by Boisduval to contain the single Madagascar species *rabena*. Another closely related species from the African mainland, *gallene*, has also been included in this genus. The genitalia of these two species, when compared with *daedalus*, indicate that they belong in *Hamanumida*. The only differenecs are those of maculation, slight changes in the shape of the wings, the absence of a closed cell in the secondaries, and the origin of the humeral as discussed previously.

Cynandra, the genotype of which is *Papilio afer*, a synonym of *Papilio opis*, contains only one species. In venation, it differs in having an open cell instead

of a closed cell in the secondaries; and R_2 arises slightly beyond the end of the cell of the primaries. The male genitalia of *opis* and *daedalus* are very similar, although the former has a proportionately shorter uncus, along with other minor characters which are only of specific rank.

Euryphura was erected by Staudinger to include three species: *porphyrion* Ward; *doralice* Hewitson; and *plautilla* Hewitson. Since no genotype has been designated, I have selected *plautilla*. Aurivillius (1925) has included six species in this genus. Its separation from *daedalus* was based on the following characters: the lower discocellular of the primaries of *daedalus* joins M_3 at a greater distance than the length of the upper discocellular, from the point of contact of M_3 and Cu_1. In *Euryphura*, this distance is less than the length of the upper discocellular. The humeral vein of the hindwing in *Euryphura* arises at the point of contact of Sc and R, while in *daedalus*, slightly beyond. The genitalia indicate that the two are congeneric, and they are treated as such in this paper.

Pseudargynnis, with only one species *aegemone*, which is the genotype, is another mimicking form. R_3 of the forewing originates beyond the cell; and the cell of the hindwing is open. The structure of the genitalia again indicate the close relationship and congeneric status of *Pseudargynnis* and *Hamanumida*.

Diestogyna, the genotype of which is *veronica* by monotypy, is a large group in which Aurivillius (1925) has included 46 species. These differ from *daedalus* only by the point of contact of the lower discocellular of the forewing with M_3, as in *Euryphura*. Otherwise, they are identical in venation. The male genitalia has a short bifurcate uncus typical of *Hamanumida*.

Crenidominas, the genotype of which is *concordia*, is another monotypic genus which is considered here as belonging to *Hamanumida*. It can be distinguished from *daedalus* by the branching of R_2 from the apex of the cell in the primaries, instead of before the end of the cell. The humeral arises at the point of bifurcation of Sc and R. In this latter character, they are very similar to *Euryphura*, and this is substantiated further by the male genitalia. *Hamanumida achlys* and *H. concordia* have almost identical male genitalia which can only be distinguished by slight differences in the valves.

Hamanumida is a large diversified genus, with a number of highly developed mimicking forms. These mimics, with their accompanying specializations, have led to the erection of a number of monotypic genera to contain them. Species such as *concordia*, *aegemone*, *rabena* and *daedalus* represent the more specialized species in the genus, while those species formerly included in *Diestogyna* and *Euryphura* are more representative on the basis of maculation and morphology. The relatively short uncus of those species which were included in *Diestogyna*, along with the maculation and venation, indicate that they are probably the most primitive species of *Hamanumida*, and probably arose from *Harma*. The long feathery horizontal laterodorsal spines of the larvae would indicate the relationship of this genus to the *Euthalia* stem. The one character which is diagnostic for the genus, and is present in all of the species, is the bifurcata uncus.

Venation (figures 20 & 23-25).—The following description is that of the genotype, *Papilio daedalus* (figure 20). Primaries: the subcostal vein is slightly curved at the base, terminating slightly beyond the middle of the costal margin. R_1 branches two-thirds the length of the cell, and R_2 arises halfway between this point and the cell apex. Both of these veins meet the costal margin. R_3 branches beyond half the distance from the end of the cell to the apex of the wing, terminating at the apex of the primaries. R_4 and R_5 are short, meet the outer margin, and branch halfway between the origin of R_3 and the outer margin of the wing. Sc, R_1, R_2 and R_3 are parallel and approximate. M_1 and M_2 are slightly bowed; M_3 is obtusely angulate. The first anal is preserved as a small spur at the base of the cubitus; the second anal is straight and parallel to the inner margin. The cell of the forewing is two-fifths the length of the wing, fairly broad. The middle discocellular is well developed and broadly concave basally. The lower discocellular is one and one-half times as long as the middle, weakly concave basally, meeting M_3 beyond that vein's point of contact with Cu_1. Secondaries: the humeral is evenly curved and appears to arise at the point of contact of Sc and R (Figure 3), because the bases of these veins are approximate but not fused. The cell is short and broad, closed by a thin, well developed vein which meets M_3 only slightly beyond its junction with Cu_1.

Numerous variations of the above venation exist among the species of this genus. The principal characters among them being: the shifting of the radial branches distally (figures 23-25); the loss of the lower discocellular of the hindwing; and the bases of Sc and R in the hindwing. These have all been used as generic characters in subdividing this genus.

The branching of the radius in *achlys* (formerly in *Euryphura*) is similar to that of *Hamanumida daedalus* except that R_3 originates more distal to the apex of the cell. In *galene* and *rabena* (formerly in *Aterica*), the radial branching is almost identical to that of *daedalus*. R_3 may arise shortly beyond the cell, or as in *daedalus*. In *concordia* (formerly in *Crenidominas*), R_1 originates slightly before the end of the cell, and R_2 and R_{3-5} bifurcate at the apex of the cell. R_3 branches more distally than in *daedalus*. This shifting of R_2 is more pronounced in *opis* (formerly in *Cynandra*), in which R_1 arises before the end of the cell, while R_2-R_5 are stalked, and R_2 branches slightly beyond the cell. This is culminated in *nyassae* (formerly in *Pseudargynnis*), in which R_2 arises halfway between the end of the cell and the apex of the wings.

The lower discocellular of the hindwings, if present, is the same as in *daedalus;* however, it has completely disappeared in species belonging to the former genera *Pseudargynnis, Cynandra* and *Aterica*. The origin of the humeral is controlled by the position of the bases of Sc and R. In *concordia* and *achlys,* these bases have fused completely so that the humeral arises from the point of bifurcation of these veins. In *rabena, galene* and *nyassae,* the bases of these veins have become more divergent so that their point of bifurcation is markedly basal to the point of origin of the humeral (figure 5). All of the other species are as in *Hamanumida daedalus*.

Male genitalia (figures 56-58).—*Hamanumida daedalus* is characterized by an elongate tegumen which is slightly curved dorsally, and rather heavily

chitinized. The uncus is divided lengthwise into two halves which are independently articulated to the posterior portion of the tegumen. These are two-thirds as long as the tegumen, narrow, slightly curved, and pointed at the tips. The gnathos has been completely lost. The vinculum is fairly broad and continuous with the short saccus. The valve is slightly longer than the tegumen. The costal fold is produced into a lobe toward the base which bears short spines. The saccular fold is narrow. The tip of the valve is turned dorsally at the apex and bears numerous short teeth.

Although the genitalia vary with the species, two structures are diagnostic of the genus and distinguishes them from all other Limenitines. These are the bifurcate uncus and the reduced gnathos. In all of the species of *Hamanumida*, the uncus is bifurcate and articulated to the tegumen. The shape varies from relatively short hooks in species which were formerly included in *Diestogyna;* to downward curved hooks which are one-half as long as the tegumen in *rabena*. In *achlys* and *concordia*, the uncus is straight and pointed. The gnathos is most strongly developed in *rabena*. In *achlys* and *concordia*, the uncus is straight and pointed. The gnathos is most strongly developed in *rabena*. In *achlys* and *concordia*, it is relatively thin and poorly developed, but still fused at the tip. In the species formerly included in *Diestogyna*, the gnathos is short and vestigial, finally disappearing in *daedalus* and *nyssae*. The valves vary in shape and ornamentation, and are useful in distinguishing species. Also the proportions of the tegumen, vinculum and saccus vary among the species and are useful as diagnostic characters.

The palpi of *Hamanumida* vary only slightly. The basal segment is strongly curved, and ventrally clothed with fairly long hairs. The second segment is slightly curved basally, otherwise straight, from two to three times as long as the basal segment. The apical segment is short, usually two-thirds as long as the basal segment, narrow, and may be broadly pointed or rounded at the tip. The eyes are naked. The antennae vary from one-half to two-thirds the length of the primaries, and terminate in an elongate narrow club.

The shape of the wings vary. In *Hamanumida daedalus*, the wings are broad; the costal margin of the primaries is slightly curved; the outer margin weakly convex; the inner margin straight; the anal angle obtuse. The hindwing is subovate, with weak crenulations on the outer margin. *Nyassae* and *concordia* are similar, although the outer margin of the primaries is straight or weakly concave, and the inner angle is approximately 90 degrees. The secondaries of these two species, though still subovate, have weakly projecting lobes at the anal angle. In *rabena*, the primaries are similar to *daedalus* although the apex of the primaries is more angular, and the secondaries tend to be quadrate because of the increased length of M_3 and Cu_1. The primaries of *opis* have a concave outer margin, with a rounded apex and anal angle; Cu_1 of the secondaries is produced into a short lobe and the wings tend to be quadrate. The primaries of *achlys* are very falcate, with a strongly concave outer margin, while the secondaries are produced at the anal angle.

The color and maculation of this genus is variable because of the great tendency for mimicry in this group. *Mamanumida concordia* has the purple iridescence on the upper side, and the brilliant orange maculation on the lower

surfaces typical of *Crenis rosa*. *Hamanumida hegemone* has the Argynnid pattern of *Atella phalanthe* of which it is an excellent mimic. The females of *Hamanumida rabena* and *H. galene* are fairly good mimics of the Danaid genus *Amauris*. *Hamanumida daedalus* has the broad wings and the bright orange maculation of the lower surface which suggests *Crenis rosa* although the upper surfaces differ. The former genera *Diestogyna* (some females mimic *Danaus chrysippus*) and *Euryphura* probably represent the normal maculation and color. They also tend to be sexually dimorphic. The males usually have an iridescent green or blue color, sometimes purple, with underlying transverse rows of dark spots which frequently fuse into bands. The lower surfaces have a tendency to be cryptic, mottled, with the ground color varying from bright orange-brown to dull brown, with a pattern often suggestive of *Harma*. The lower surfaces also are cryptic. The transverse bands in the cell are present in all of the species.

Life history.—The knowledge is limited to that of the genotype, *Hamanumida daedalus*. Aurivillius (1894) mentions that the larvae are similar to those of *Euphaedra*, having the laterodorsal spines elongate, feathery, and horizontal. The larvae are greenish in color, and usually sit along the midvein of the upper side of leaves, where they are difficult to see. The pupa is more slender than that of *Euphaedra*, and lacks the lateral and dorsal elevations.

Habits.—Trimen (1887) mentions that *Hamanumida daedalus* has been collected on bare patches of ground on rocky hills, and also along sandy footpaths on low ground where they sit with their wings expanded. Their flight habits are supposed to be similar to those of *Vanessa cardui*. Aurivillius (1925) mentions that this species is peculiar in that it also occurs in open areas which may be entirely lacking in forests. The species which were formerly included in *Diestogyna* are inhabitants of deep forests.

Distribution.—The genus *Hamanumida* exhibits the greatest degree of speciation in West Africa, from Sierra Leone south to Angola. Fewer species occur in the Congo, Rhodesia, and along the eastern coast from Ethiopia south to Mozambique. One species, *Hamanumida rabena*, is found in Madagascar. *H. daedalus* is the most widely distributed species of the genus. It occurs throughout continental Africa south of the Sahara Desert, extending as far north as southeastern Arabia, and southward into the Union of South Africa, but not occurring in the Cape of Good Hope.

Genus EUPHAEDRA Hübner

1807. *Najas* Hübner (nec *Najas* Hübner, 1806), Exot. Schmett., vol. 1, pl. 60. Genotype: *Najas themis* Hübner, 1807. (The name *Najas* Hübner, 1807, is not used for this genus in anticipation of a suspension of the rules by the International Commission on Zoological Nomenclature.)

1819. *Euphaedra* Hübner, Verz. Bek. Schmett., p. 39. Genotype: *Papilio cyparissa* Cramer, 1775.

1840. *Romaleosoma* Blanchard, Hist. Nat. Ins., vol. 3, p. 448. Genotype: *Papilio eleus* Drury, 1782.

1847. *Euriphene* Boidduval, Voy. Deleg., vol. 2, p. 592. Genotype: *Euriphene caerulea* Boisduval, 1847.

1850. *Euryphena* Feisthamel, Ann. Soc. Ent. France, vol. 8, p. 251. Genotype: *Euriphene caerulea* Boisduval, 1847.
1850. *Euryphene* Feisthamel, Ann. Soc. Ent. France, vol. 8, p. 253. Genotype: *Euriphene caerulea* Boisduval, 1847.
1850. *Euryphene* Westwood, Gen. Diurn. Lepid., p. 285. Genotype: *Euriphene caerulea* Boisduval, 1847.
1850. *Romalaeosoma* Westwood, Gen. Diurn. Lepid., p. 283. Genotype: *Papilio eleus* Drury, 1782.
1892. *Harmilla* Aurivillius, Ent. Tidskr., vol. 13, p. 200. Genotype: *Harmilla elegans* Aurivillius, 1892.

Two groups which comprise the genus *Euphaedra,* have been considered distinct genera by previous authors. These are *Euphaedra* and *Euriphene*. Aurivillius (1925) distinguished the two genera by the color of the palpi, those of *Euphaedra* are bright yellow-orange, while those of *Euriphene* are dull gray. He further mentions that the two genera are entirely in agreement on morphological characters and cannot be separated. The females of *Euriphene* tend to be dimorphic, while those of *Euphaedra* resemble the males. Since the two genera are identical in venation, structure of the male genitalia, and in their life-histories, they are considered as one in this paper.

Venation (figure 22).—Primaries: the cell is broad, and two-fifths the length of the wing. The subcostal vein is slightly curved, meeting the costal margin three-fifths of its length from the base. R_1 and R_2 arise before the end of the cell, and meet the costal margin. R_3 arises shortly beyond the cell and terminates at the apex of the wing. R_4 and R_5 branch very near the outer margin. Sc, R_1, R_2, R_3 and R_{4-5} are parallel and approximate. Both M_1 and M_2 are curved; M_3 is broadly angulate towards its base. Cu_1 and Cu_2 are straight. The first anal is preserved as a well developed spur at the base of the cubitus; the second anal is straight and parallel to the inner margin. The middle discocellular is concave basally; the lower discocellular may be strongly or weakly concave, meeting M_3 beyond that vein's contact with Cu_1. The lower discocellular is two or two and one-half times as long as the middle. On the secondaries, the bases of Sc and R may be approximate or fused (figures 3 and 4), so that the humeral seems to arise at their point of bifurcation. The cell is short and broad, and closed by a well developed vein which meets M_3 slightly beyond that vein's contact with Cu_1. The venation seems to be constant among all of the members of the genus.

Male genitalia (figure 62).—The tegumen is well developed, curved dorsally. The uncus is as long as the tegumen, broad, curved, terminating in a small hook. The gnathos is long, broad, widening distally, and fused at the apex. The vinculum is fairly heavy, and the saccus is broad and as long as the tegumen. The valves are simple, smoothly rounded at the apex (with the exception of *senegalensis* in which the valves are more elongate and bear small spines at the apex). The ventral surface of the valve has a broad protruding ventral lobe. The saccular and costal folds are well developed. The aedeagus is as long as the valve, curved, and pointed distally. The variation among the species is limited to proportions of the tegumen, uncus, and contour of the valves. Otherwise, they are very homogeneous.

The antennae are one-half to three-fifths as long as the primaries, with a long narrow terminal club. The eyes are naked. The first segment of the palpus is curved, twice as long as wide; the second segment is two and one-quarter to two and one-half times as long as the first, curved basally, and straight distally; the terminal segment is one-half to two-thirds as long as the first segment, narrow, and either rounded or bluntly pointed at the tip. The shape of the wings are fairly variable in the genus, although normally they are fairly broad. In the primaries, the costal margin is strongly curved; the apex of the wing is rounded in such species as *harpalyce*, while in *pseudocalia*, the apex is strongly angulate. The outer margin may be almost straight as in *tentyris*, or concave. In the latter case, the primaries have a tendency to be falcate. The inner angle is weakly rounded, and the inner margin is straight. On the hindwings, the costal margin may be curved or almost straight. The apex of the secondaries tends to be angulate. The outer margin is usually rounded and crenulate, although occasionally slightly produced at veins M_3 and Cu_1 giving a subquadrate shape to the wing. The anal angle is weakly angulate or rounded, but in *phantasiella*, it is produced into a well developed lobe.

This genus is extremely variable in maculation. One group which originally was included in *Euriphene*, bears close resemblance to species of *Hamanumida*, having a brown color on the upper side, with an intricate arrangement of lighter transverse bars, and a semicryptic pattern below. Other species usually have a brown or brownish-black ground color above, with a yellow or white subapical band on the primaries, and an iridescent green or blue suffusion on the wing, suggestive of some of the Asian Euthaliids. *Euphaedra eleus* has an orange-brown posterior area of the primaries, and the basal and discal areas of the secondaries in the same color. The lower surface of many species of *Euphaedra* tend to become immaculate and may be homogeneous orange, brown, yellow, green, or blue-green. The ventral surfaces are often more brilliant in some species with beautiful patterns of red, green, blue, yellow, and black.

Life history.—The early stages of *Euphaedra ceres ravola, Euphaedra themis aureola* and *Euphaedra ceres ceres* have been described or illustrated by Aurivillius (1894). These indicate the close relationship of the genus to the Asian Euthaliids.

Egg.—Unknown.

Larvae.—The caterpillar of *Euphaedra ceres ravola* is violet, with yellowish-white intersegmental cross-bands. The color turns to green before pupation. The entire body is clothed with fine thin hair. A row of laterodorsal spines extends from segments two to eleven. These spines are very long, horizontal in position, clothed with long fine bristles giving them a featherlike appearance. They are terminated by one or more long filamentous hairs. The degree of plumosity varies somewhat with the species, but it is always much more pronounced than in any other African genus.

Chrysalis.—The various species of *Euphaedra* have short broad chrysalids. The head bears at the apex, two short protuberances. The dorsal surface is longitudinally angulate. A raised ridge, sometimes very protruding, is found

on the dorsal surface of the third abdominal segment. The chrysalis is broadest at this point, tapering rapidly to the cremaster.

Habits.—Trimen (1887) writes that the species of *Euphaedra* are usually found in shady forests. They are relatively inactive, and frequently congregate in numbers around puddles or moist areas in the woods.

Distribution.—This genus is found from Senegal to Angola in west Africa; and from Ethiopia south to Natal in eastern Africa. It does not occur in Madagascar. The greatest diversity of species is found in the region from the Cameroons south into Angola, and east into the Belgian Congo, where they are fairly abundant in the deep forests.

Genus EURYPHAEDRA Staudinger

1891. *Euryphaedra* Staudinger, Iris, vol. 4, p. 102. Genotype: *Euryphaedra thauma* Staudinger, 1891.

Euryphaedra is a monotypic genus erected by Staudinger for *Euryphaedra thauma*, a species occurring in the interior of the Cameroons and French Congo. Unfortunately, no specimens of this species are available to the author for study, and its true generic status cannot be determined. Staudinger, in his original description, mentions that this butterfly comes between *Euriphene* and *Euphaedra*. The males approach *Euphaedra*, while the females are similar to species of *Euriphene* such as *porphyron*, *doralice* and *plautilla*. Since both of these genera are considered as one in this paper, it is not at all improbable that *Euryphaedra* might be a synonym of *Euphaedra*. Staudinger mentions that the principal character separating *Euryphaedra* from other African genera is the produced anal lobe in both sexes of *thauma*. In the species of *Euriphene*, if the lobe is present, it is only produced in the males. The venation, according to Staudinger, is similar to both *Euriphene* and *Euphaedra*.

Aurivillius (1925) adds little to the knowledge of the insect. He does mention however, that the cell is closed in both wings; that the veins anterior to the cell are subparallel and approximate; R_3 arises shortly beyond the cell in the female; and the humeral arises beyond the point of bifurcation of Sc and R. None of these characters are sufficiently diagnostic to distinguish it from *Euphaedra*.

The forewing is rather elongate and narrow; the costal margin curved; the apex of the wing rounded; the outer margin almost straight; the inner angle obtuse; and the inner margin straight. On the hindwing, the costal margin is curved; the outer margin convex; but the anal angle is produced into a broad rounded lobe. The ground color above is iridescent green with black markings along the anterior portion of the primaries, and the limbal area of the secondaries; the costal margins of both wings are bordered with black. On the lower surface, the maculation is similar to the upper side although the black markings are reduced and the green color is replaced by yellow on the posterior portion of the primaries, and the basal area of the secondaries. No information is available on the life history or habits of this species.

The available information on *Euryphaedra* seems to indicate that it may be synonymous with *Euphaedra*. This is based on venational characters. More

complete studies of venation, along with studies of the male genitalia would be necessary to determine if this is true. It is tentatively considered as a distinct genus in this paper until further information is available.

Genus EUTHALIA Hübner

1819. *Symphaedra* Hübner, Verz. Bek. Schmett., p. 40. Genotype: *Symphaedra alcandra* Hübner, 1819.
1819. *Euthalia* Hübner, Verz. Bek. Schmett., p. 41. Genotype: *Papilio lubentina* Cramer, 1777.
1829. *Aconthea* Horsefield, Cat. Lepid. Ins. Mus. E. I. C. (2) *explic.*, pl. 5, 8., *id.* 1830. Zool. L., vol. 5, p. 67. Genotype: *Aconthea primaria* Horsefield, 1829.
1832. *Lexias* Boisduval, *in* d'Urville, Voy. Astrolabe, Ent., vol. 1 (Lepid.), p. 125. Genotype: *Papilio aerope* Linnaeus, 1758.
1836. *Adolias* Boisduval, Spec. Gen. Lepid., vol. 1, pl. 3 & 8. Genotype: *Papilio aconthea* Cramer, 1777.
1848. *Acontia* Westwood, Cabinet Or. Ent., p. 76, pl. 37. Genotype: *Acontia doubledayi* Westwood, 1848.
1857. *Abrota* Moore, *in* Horsfield & Moore, Cat. Lep. E. Ind. Mus., p. 176. Genotype: *Abrota ganga* Moore, 1857.
1861. *Itanus* Felder, Nova Acta Akad. Leop. Carol., vol. 28, p. 34. Genotype: *Adolias anosia* Moore, 1857.
1868. *Tanaecia* Butler, Proc. Zool. Soc. Lond., p. 610. Genotype: *Adolias pulasara* Moore, 1857.
1868. *Neurosigma* Butler, Proc. Zool. Soc. Lond., p. 615. Genotype: *Adolias siva* Westwood, 1850.
1881. *Dolpha* Moore, Lepid. Ceylon, vol. 1, p. 33. Genotype: *Papilio evalina* Cramer, 1790.
1888. *Felderia* Semper, Reisen Phil., Lepid., p. 88. Genotype: *Felderia phlegethon* Semper, 1888.
1893. *Nora* deNiceville, Journ. Bombay Nat. Hist. Soc., p. 44. Genotype: *Adolias kesava* Moore, 1859.
1895. *Cynitia* Snellen, Tijd. voor Ent., vol. 38, p. 20. Genotype: *Felderia phlegethon* Semper, 1888.
1898. *Bassarona* Moore, Lepid. Indica, vol. 3, p. 48. Genotype: *Adolias teuta* Doubleday & Westwood, 1850.
1898. *Limbusa* Moore, Lepid. Indica, vol. 3, p. 48. Genotype: *Adolias nara* Moore, 1868.
1898. *Mahaldia* Moore, Lepid. Indica, vol. 3, p. 48. Genotype: *Adolias sahadeva* Moore, 1859.
1898. *Rangasa* Moore, Lepid. Indica, vol. 3, p. 48. Genotype: *Adolias dunja* Doubleday & Hewitson, 1850.
1898. *Labranga* Moore, Lepid. Indica, vol. 3, p. 49. Genotype: *Adolias durga* Moore, 1857.
1898. *Zalapia* Moore, Lepid. Indica, vol. 3, p. 49. Genotype: *Adolias patala* Kollar, 1844.
1898. *Camaraga* Moore, Lepid. Indica, vol. 3, p. 49. Genotype: *Cynthia damalis* Erichson, 1834.
1898. *Marthisa* Moore, Lepid. Indica, vol. 3, p. 49. Genotype: *Symphaedra canescens* Butler, 1868.
1898. *Senadipa* Moore, Lepid. Indica, vol. 3, p. 49. Genotype: *Lexias satrapes* Felder, 1861.
1898. *Bucasia* Moore, Lepid. Indica, vol. 3, p. 49. Genotype: *Adolias calliphorus* Felder, 1861.
1898. *Chucapa* Moore, Lepid. Indica, vol. 3, p. 49. Genotype: *Adolias franciae* Gray, 1846.
1898. *Kirontisa* Moore, Lepid. Indica, vol. 3, p. 49. Genotype: *Adolias telchinia* Menetries, 1857.
1898. *Haramba* Moore, Lepid. Indica, vol. 3, p. 49. Genotype: *Adolias appiades* Mene-

tries, 1857.

1898. *Passirona* Moore, Lepid. Indica, vol. 3, p. 49. Genotype: *Euthalia amisa* Grose-Smith, 1889.

1898. *Saparona* Moore, Lepid. Indica, vol. 3, p. 49. Genotype: *Adolias cibaritis* Hewitson, 1874.

1898. *Sonepisa* Moore, Lepid. Indica, vol. 3, p. 49. Genotype: *Adolias kanda* Moore, 1859.

1898. *Tasinga* Moore, Lepid. Indica, vol. 3, p. 49. Genotype: *Adolias anosia* Moore, 1857.

1898. *Auzakia* Moore, Lepid. Indica, vol. 3, p. 146. Genotype: *Limenitis danava* Moore, 1886.

The generic names of this group have been in some confusion. *Symphaedra* and *Euthalia* were erected by Hübner simultaneously, with the former having page priority. However, most authors have accepted the name *Euthalia* in application to the members of this genus. The International Commission of Zoological Nomenclature passed an opinion in 1945, retaining the name of *Euthalia*. The summary of this opinion, number 167, reads as follows:

"Summary: Under suspension of the rules it is hereby declared that page priority shall not be invoked to secure precedence for *Symphaedra* Hübner (1819) (Type: *Symphaedra alcandra* Hübner) if and when it may be desired on taxonomic grounds to place *Symphaedra alcandra* Hübner and *Papilio lubentina* Cramer in different genera. The name *Euthalia* Hübner (1819) (Class *Insecta*, Order *Lepidoptera*), with the type indicated above, is hereby added to the *Official List of Generic Names in Zoology* as Name No. 613."

Symphaedra consequently becomes a synonym of *Euthalia*, but the name is still available if the genotypes of each are found not to be congeneric. *Symphaedra* is considered as a synonym of *Euthalia* in this paper.

The genus *Euthalia* has been subdivided by many authors, with Moore (1898) proposing the greatest number of generic names. However, his classification has not been accepted by subsequent authors. Frühstorfer (1927) recognizes four genera: *Neurosigma; Abrota; Tanaecia;* and *Euthalia*. Schatz (1892) recognized the following: *Abrota; Neurosigma; Euthalia; Tanaecia;* and *Symphaedra*. All of these are considered as comprising a single genus in this paper. *Neurosigma* was separated from *Euthalia* because the cells of both wings are closed. *Abrota* has the cell of the forewing closed, while that of the hindwing is open. The name *Symphaedra*, Schatz applied to *dirtea* and its relatives having a closed cell of the primaries, an open cell of the hindwing, and exhibiting sexual dimorphism. These three "Genera" are further characterized by the simple curved humeral of the hindwings. *Tanaecia* and *Euthalia* are supposedly distinguished by the shape of the third palpal segment which is longer and more pointed in the former, while shorter and more rounded in the latter. This character is variable and not diagnostic. Chart 2 shows the variation in venational and genitalic characters of representative species of the genus. It can be seen that all the characters vary independently of one another, and no single combination can be used for subdividing the genus. Any division, therefore, must be based on a single character and would result in an unnatural classification. Consequently, they are considered as one genus in this paper.

Frühstorfer placed *Neurosigma* and *Abrota* in the tribe *Limenitidi*, while *Tanaecia* and *Euthalia* were included in the *Euthaliidae*. However, the geni-

talia indicate that all belong to the Euthaliids. He considered *Abrota* as transitional between the two tribes, but again the genitalic structure indicates congeneric relationship with *Euthalia*. Both of these groups have a well developed anellus. Frühstorfer (1927) also placed emphasis on the closed cells of these two genera. In the African genus *Euphaedra*, which is probably the primitive form of *Euthalia*, both cells are normally closed. The specialization among species of *Euthalia* seems to be the loss of the lower discocellular of the hindwing. The forking of the humeral vein, and its origin beyond the point of bifurcation of Sc and R also are specializations. *Neurosigma* and *Abrota*, therefore, are representative of the more primitive species of *Euthalia*. If the life histories of these groups were known, their position could be easily determined by the structure of the laterodorsal spines of the larvae.

CHART 2.—Variation in the genus *Euthalia*.

Species	Cell of Forewing	Cell of Hindwing	Humeral Vein	Bases of Sc & R	Valve of Genitalia
nara	closed	closed	curved	divergent	simple
kardama	closed	closed	curved	divergent	ornamented
jama	open	open	curved	divergent	simple
alpheda	open	open	curved	divergent	simple
adonia	open	open	curved	divergent	ornamented
kesava	open	open	forked	divergent	simple
appiades	open	open	forked	divergent	simple
cibaritis	open	open	forked	divergent	ornamented
amisa	open	open	forked	divergent	ornamented
confinis	closed	open	curved	fused	ornamented
fraterna	closed	closed	curved	fused	ornamented
dirtea	closed	open	curved	divergent	ornamented
teuta	closed	closed	curved	divergent	simple
aeroppus	closed	open	curved	divergent	ornamented
nais	open	open	curved	divergent	ornamented

Venation (figure 21).—Primaries: the subcostal vein is slightly curved and ends three-fifths of the length of the costal margin from the base of the wing. R_1 and R_2 arise before the end of the cell. R_3 arises beyond the cell, halfway or slightly less than half the distance between the end of the cell and the apex of the wing, terminating at the apical angle. R_4 and R_5 usually branch near the outer margin but in *doubledayi*, somewhat more basally. Sc, R_1, R_2 and R_3 are subparallel, often very close together. M_1 and M_2 are slightly curved; M_3 is broadly curved near the base. Cu_1 and Cu_2 are almost straight. The first anal is preserved as a spine at the base of the cubitus; the second anal is parallel to the inner margin. The cell is two-fifths as long as the wing, fairly broad. The middle discocellular is basally concave. The lower discocellular is lacking in many species such as *jama*, *kesave*, *cibaritis* and *amisa*. Secondaries: the humeral may be curved or bifurcate; if the latter, the cells of both wings are always open. The bases of Sc and R are strongly divergent (figure 5) in species such are *kardama*, *nara* and *monina;* in this case, the humeral arises

some distance beyond their point of contact. However, in many other species such as *confinis, amisa, cibaritis* and *doubledayi,* the bases are only weakly divergent (figure 3), and the humeral appears to arise at the point of bifurcation of these veins. In the latter case, usually the cell of the hindwing is open. The cell may be open or closed.

Male genitalia.—(figures 60, 61, 63-66) These vary tremendously throughout the genus and provide very useful characters for distinguishing species. The shape of the tegumen is fairly constant, usually heavy, curved dorsally. The uncus varies in length and may be evenly curved, semiangulate, almost straight or humped, usually bearing a short hook at the tip. The gnathos is usually well developed, elbowed distally and fused at the apex. In *palguna* (figure 60), a series of small teeth are present at the apex of the gnathos. The vinculum normally tends to be slender, and the saccus is usually well developed, but simple. The anullus is well developed, with two large rounded lateral lobes. The valves normally are fairly long, with the dorsal and ventral aspects evenly sinuate. The apex may be smoothly rounded, or ornamented with short teeth. The costal and saccular folds are well developed. In species such as *sikanda,* the valves are extremely attenuate. Two species of *Euthalia* deserve special mention because they possess the most highly specialized reproductive organs of the genus. These are *amisa* and *leucotaenia* (figure 61), which are unquestionably closely related. In these species, the tegumen, vinculum and saccus are heavily chitinized, and the gnathos is lost. The uncus is extremely long, narrow, and swollen at the apex. It is completely fused to the tegumen. The valves again are enormous, but plain; and the aedeagus is simple but again elongate.

The antennae are one-half the length of the forewing, sometimes slightly longer. The eyes are naked. The first segment of the palpus is short and curved; the second segment two and one-half times as long as the first, curved, and slightly narrower basally; the third segment is one-half to two-thirds as long as the first and usually bluntly pointed. The wings are broad, and tend to be more or less uniform in shape throughout the genus. The costal margin of the primaries is curved; the apical angle is only weakly rounded; the outer margin may be straight or weakly concave; the inner angle usually is about 90°; the inner margin straight or weakly sinuate. In *Euthalia evalina,* the primaries are falcate with a rounded produced apex, and strongly concave outer margin. The secondaries are rounded, with the costal margin curved; the outer margin strongly convex, often crenulate; the inner angle rounded. The anal angle is occasionally produced into a weak lobe in the males of some species.

In color and maculation, *Euthalia* is a variable genus. The ground color of the upper surface is usually a dark shade of brown. A white or yellow band, which may be broken into spots or disappears entirely, traverses the middle of the wings. On the lower surface, the pattern of the upper side is usually duplicated, although the ground color is often suffused with tan, yellow, or occasionally a pale iridescence of green or blue. Some species such as *Euthalia confinis* have a pattern which is suggestive of the genus *Neptis.* Although the males and females of most of the species of *Euthalia* have similar maculation,

Euthalia dirtea exhibits marked sexual dimorphism. The most distinctive color pattern is that found in *Euthalia doubledayi* and its relatives, in which the wings have a complex lacey network of black and white.

Life history.—The early stages of this genus have been summarized by Stichel (1909), and detailed descriptions and illustrations of many of the species have been made by Moore (1898). They are all relatively uniform in character, and easily identified.

Egg.—Unknown.

Larvae.—The laterodorsal spines are present on body segments two to eleven. They are extremely long, horizontal in position, covered with long thin hairs giving them a feathery appearance. This character is present also in the African genus *Euphaedra*, to which *Euthalia* is closely related, and serves to distinguish these two genera from all of the other Limenitines. The infrastigmatal spines are apparently lost. The caterpillars are similar to other Limenitines in that they start feeding at the tip of a leaf, working backwards, but still leaving the main stem of the leaf undisturbed. They feed on members of the *Ebenaceae, Myrtaceae, Melastomaceae* and *Loranthaceae*.

Chrysalis.—Usually short, compressed, the head terminated by two pointed protuberances. The abdominal segments are short. The chrysalis is broadest in the middle, tapering abruptly, posteriorly.

Habits.—The species of *Euthalia* are most abundant at low elevations, although some species are found in alpine zones. They occur commonly in the dense forests, often frequenting open sunny areas. Their flight is usually slow, and they are often found sitting on the leaves of bushes and low trees with their wings expanded. Fermenting fruits serve as excellent bait for collecting species of this genus.

Distribution.—The genus *Euthalia* ranges from India through south and central China, eastward through the Malay Peninsula to the Bismarck Archipelago. They occur commonly in the Philippines and Formosa. No species are recorded from Japan or Australia.

PHYLOGENY OF THE TRIBE LIMENITINI

The phylogeny of the *Limenitini* is difficult to determine because of the absence of fossil forms. Consequently, an analysis must be based on the species in existence today. The best source of data for comparison, are characters of the larval and pupal stages. The adults vary tremendously, although genitalia and occasionally venation have been helpful. Distribution has helped only in a few restricted groups. The problem has been to select those characters which seem to represent progressive stages in development, and from these, gain some concept of the phylogeny of the tribe. Some of the most important of these have been listed in chart 3; and a phylogenetic tree (figure 67) graphically summarizes the author's conclusions. Unquestionably, further studies will show that some of these conclusions are in error. This can be partially attributed to the incomplete knowledge of the life histories. Perhaps other characters will be discovered, of which the author is unaware, which might also prove that the conclusions in this paper must be altered. The author hopes that the

suggestions presented here will form a basis for future studies, and simultaneously give some clue to the interrelationships of the various genera of the tribe *Limenitini*.

CHART 3.—Comparison of Generic Characters.

Structure	Variation	Euthalia	Eurytphaedra	Euphaedra	Hamanumida	Catuna	Neptis	Limenitis	Lebadea	Pseudacraea	Pseudathyma	Harma	Parthenos
Cell of hindwing	closed	×	×	×	×				×	×		×	×
	open	×			×	×	×	×			×	×	
Cell of forewing	closed	×	×	×	×	×		×	×	×		×	×
	open	×					×				×	×	
Bases of Sc & R	fused	×		×	×		×	×		×	×	×	
	divergent	×	×		×	×			×				
Latero-dorsal spines of larvae	subequal	×		×	×	×		×		×		×	×
	unequal						×	×					
	erect						×	×		×		×	×
	horizontal	×		×	×	×							
Shape of pupae	long						×	×		×		×	×
	medium				×	×							
	short	×		×									
Dorsal lobe of pupae	present						×	×					
	absent	×		×	×	×	×			×		×	×

The base of the stem of the tribe *Limenitini*, or the archetype, is probably no longer in existence. From it have evolved two genera: *Parthenos* and *Harma*. The latter is the most primitive of the true Limenitines. *Parthenos*, on the other hand, exhibits many characters of the primitive Limenitines, but has become specialized along its own particular line. From the morphology of these two genera, we might conclude the archetype as having the following characters. In the adults, the cells of both wings are closed; the humeral might have been plain or bifurcate; vein R_2 arose before the end of the cell; the first anal was preserved as a short spur at the base of the cubitus; and a subcostal cell was probably present on the secondaries. In the male genitalia, the uncus and gnathos were probably short; the valves were probably somewhat ornate. The larvae had both the laterodorsal and infrastigmatal rows of spines extending from segments two to eleven; these spines were of medium length, erect, and lightly clothed with short bristles. The chrysalis was of normal length, with little ornamentation. The maculation of the lower surface of the adults was probably cryptic. Since *Parthenos* is found in the Indoaustralian region,

while *Harma* in Africa, the archetype probably occurred in the Old World, perhaps in southwestern Asia.

Parthenos represents a sidebranch of the archetype characterized by the presence of a subcostal cell (figure 2) on the secondaries, and a complex, ornate valve of the male genitalia. The larval characters, however, are essentially similar to those of *Harma*, and for this reason they are included in the *Limenitini*. Admittedly, they are an offshoot of the main line, and are extremely primitive. The genus is small, has not given rise to any further genera, and probably represents a relict group.

Harma essentially possesses the characters of the archetype. However, we do find the following modifications occurring with the genus: the humeral is never bifurcate; Sc and R are approximate at their bases (figure 3); the valves of the male genitalia become somewhat more simplified. The larval stages essentially remain simple and primitive. Among the intrageneric variations, the cells of both wings may be closed by strong or weak discocellulars, or may be open. The latter represents a specialization within the genus, and is not significant in the direct line of descent.

Pseudathyma, as far as can be determined, represents an offshoot of some of the more aberrant species of *Harma*. It is characterized by the cells of both wings being open, and R_2 arises beyond, instead of before the cell. They are mimicking forms, and many of the mimics in the genera of the *Limenitini* are characterized by the shift of the origin of R_2. The validity of this genus is in doubt, possibly being synonymous with *Harma*. However, this cannot be determined without the male genitalia or information on the life history. Tentatively, it is placed as a specialized offshoot of *Harma*, and not in the direct line of evolution.

Arising from *Harma* are two main lines of development. These are best characterized by larval and pupal characters. The larvae of the *Limenitis* line have erect laterodorsal spines; the chrysalis is as long as in *Harma*. In the *Euthalia* line, the larvae have horizontal laterodorsal spines; and the chrysalis is shorter and broader. The phylogeny of the *Limenitis* branch will be discussed first.

Pseudacraea is an interesting genus because the majority of its species exhibit mimicry. Their maculation and wing-form, consequently offer no clues to their true relationship. However, their morphology and life histories indicate that they have probably arisen from *Harma*. *Pseudacraea* always has the cells of both wings closed; the bases of Sc and R are always approximate; the humeral is smoothly curved. The male genitalia have become extremely generalized, with the valves losing most traces of ornateness; the uncus and gnathos have increased in length; and the tegumen has become rounded dorsally. The laterodorsal spines of the larvae are erect and similar to those of *Harma*, although there is a tendency for those of segments 2, 3, and 11 to be somewhat longer than the remaining. The chrysalis is elongate and narrow, but unlike *Harma* tends to be strongly arched in many species. Intragenerically, the morphology tends to be constant with the exception of one species, *Pseudacraea coenobita*, in which R_2 shifts beyond the cell.

The position of *Lebadea* is doubtful. It is tentatively placed as arising from the *Limenitis* stem above *Pseudacraea*. This conclusion has been based on the adult stage alone. In *Lebadea*, the cells of both wings are closed; while in *Neptis* and *Limenitis*, one or both cells are open. The bases of Sc and R, however, are strongly divergent, a character occurring nowhere else in the *Limenitis* stem and appearing to be a specialized trait of this genus. The male genitalia are simplified as in *Pseudacraea*, but the uncus and gnathos are thinner than in the species of that genus. *Lebadea* represents a specialization of the Pseudacraean type; however, it still bears some similarity to *Limenitis* in basic pattern. That it is a relict group, with its small range of distribution and one or two species, is highly probable. Information on the life history would unquestionably offer some interesting data regarding its relationship to *Limenitis*.

Limenitis is a large and varied genus, however, morphologically it is quite uniform. Its relationship to *Pseudacraea* is best exemplified in the early stages. In *Limenitis opalina* and *L. sibylla*, the larvae have a complete laterodorsal row of erect spines comparable to those of *Pseudacraea*. However, specialization develops within this genus, with the tendency to have certain of these spines reduced. First, those of segments 4 and 6-9 become vestigial; and finally only the spines of the second body segment are retained. The chrysalis is still elongate, but develops a dorsal lobe which is absent in *Pseudacraea*. In venation, *Limenitis* is relatively constant and is similar to that of *Pseudacraea* except that the cell of the hindwing is always open. The male genitalia are of the Pseudacraean type, but possess a saccular lobe in all of the species except a few *Adelpha* where it has been secondarily lost.

Neptis is a specialized offshoot of *Limenitis*. This becomes evident in comparing the life histories which are remarkably similar. The chrysalids of both genera have the dorsal lobe. The larvae of *Neptis* have erect laterodorsal spines, the same ones becoming atrophied as in *Limenitis*. The adults, however, can easily be distinguished from those of *Liminitis*. In *Neptis*, the cells of both wings are open; the first anal vein has been lost; and the male genitalia have lost the saccular lobe. The intrageneric variation is discussed under that genus.

We return again to *Harma* and proceed along the *Euthalia* line in the development of the Limenitines. The first genus is *Catuna*, an offshoot of the main stem, with numerous specializations typical of the genus. These are: the bases of Sc and R are strongly divergent on the secondaries; the cell of the hindwing is open; R_2 arises beyond the cell; and R_1 coalesces with Sc for a short distance on the primaries; the humeral is reduced to a short stalk; the saccus of the male genitalia is extremely elongate. However, we do find the following characters which are of phylogenetic significance. In the male genitalia, the short uncus and gnathos, and the straight dorsal surface of the tegumen are comparable to *Harma*. The valve, however, tends to become simplified, losing its ornateness. The laterodorsal spines of the larvae are subequal, and clothed with short stiff bristles as in *Harma*, but instead of being erect, are horizontal in position. The chrysalis is shorter than in *Harma* or the gen-

era of the Limenitis line, and is comparably broader. These latter characters are typical of the base of the *Euthalia* line.

Hamanumida represents another offshoot of the main *Euthalia* line. Its most diagnostic character is the bifurcate uncus of the male genitalia, which occurs nowhere else in the Limenitines. The venation varies intragenerically. The cell of the forewing is always closed; the cell of the hindwing may be closed or open, the latter probably representing a specialization. On the secondaries, the bases of Sc and R may be closely approximate or widely divergent. In a few species, R_2 arises beyond the cell of the forewing, a specialization often accompanying mimicry. The chrysalis is essentially the same as in *Catuna*, being somewhat shorter and broader than in *Harma*. The larvae have horizontal subequal laterodorsal spines which, however, are longer than in *Catuna*, and are covered with long hairs giving them a feathery appearance. This latter trait is characteristic of the members of the *Euthalia* line beyond this point.

The genus *Euphaedra* is probably in the direct line of descent of *Euthalia*. It differs from *Hamanumida* in having a simple uncus in the male genitalia, which is proportionally longer than that of *Catuna*. The gnathos is also longer, and tends to be narrower. The dorsal surface of the tegumen is curved, and the saccus is of normal length for the tribe. The valves are simple, with a prominent ventral lobe. The venation of this genus is quite generalized, with both cells being closed; and the bases of Sc and R approximate on the hindwing. The larvae exhibit the same degree of specialization as those of *Hamanumida*; the laterodorsal spines are very long, subequal, horizontal and feathery. The chrysalis, however, is still shorter and very broad.

Euryphaedra, if a valid genus, is probably only a specialized offshoot of *Euphaedra*. It differs from this genus in having the bases of Sc and R strongly divergent (figure 5). No information is available on the life history.

Euthalia is a large genus which varies tremendously. The early stages indicate that it is closely allied to *Euphaedra* because the larvae also have long, horizontal, feathery, laterodorsal spines; and the chrysalis is short and broad. Whereas *Euphaedra* is quite generalized in venation, the majority of the species in *Euthalia* have lost the discocellulars closing the cells on one or both pairs of wings; the bases of veins Sc and R are almost invariably strongly divergent. The genitalia, although essentially similar to those of *Euphaedra*, vary tremendously and are quite highly modified. For these reasons, it is placed at the top of this line of development.

The distribution o fthe various genera of *Limenities* (figure 68) suggests some conclusions. Of the two most primitive groups, *Harma* is African and *Parthenos* occurs in Indoaustralia. Both of these genera live in tropical environments, inhabiting forest areas. No primitive Limenitines are found in the New World. The discontinuity of their distribution would indicate that at one time, they or their immediate ancestors had a wider distribution. They possibly were found throughout southern Asia and northern Africa. If this were true, we might conclude that these genera have been isolated at the perimeters of their former range, where tropical conditions suitable for their survival still exist.

CHART 4.—Distribution of the Limenitini.

Genera	Neotropical	Nearctic	Palaearctic	Ethiopian	Oriental	Australian
Parthenos					×	×
Harma				×		
Pseudathyma				×		
Pseudacraea				×		
Lebadea					×	
Limenitis	×	×	×		×	
Limenitis		×	×		×	
Adelpha	×	×				
Neptis			×	×	×	×
Neptis			×	×	×	×
Acca					×	×
Catuna				×		
Hamanumida				×		
Euphaedra				×		
Euryphaedra				×		
Euthalia					×	×

Parthenos has remained stable, exhibiting no variation leading to further evolution. *Harma,* however, is an exploding group as evidenced by the large number of species with great variation. It probably represents the morphological type from which the Limenitines have developed. Consequently, the focal point of this tribe can probably be placed in Africa. *Pseudathyma,* as mentioned before, is a specialized form of *Harma* restricted to the African continent, which is not in any direct line of descent of any higher genera.

As is to be expected, the lowest genus of the *Limenitis* line is restricted to Africa. This is *Pseudacraea.* A northward expansion occurred, and the tropical portions of southern Asia were invaded. *Lebadea* probably remains today as a somewhat specialized relict of the invaders.

This group which entered Asia varied tremendously, forming a secondary focal point of expansion. Certain species became adapted to temperate environments. These spread northward into China, westward into Europe, and finally invaded the Western Hemisphere *via* the Alaskan bridge. Others still retained the preference for tropical environments and extended their range along the East Indian chain.

The evolution of the genus *Limenitis* in the Western Hemisphere is interesting. They are divided into two subgenera: *Limenitis* and *Adelpha.* The latter is almost totally restricted to the tropical regions, while the former is only found in the temperate zone. It is highly probable that they represent two distinct invasions of the hemisphere. *Adelpha,* with its preference for warmer climates, like the most primitive Limenitines, probably came over first. Their homogeneity in maculation and morphology would possibly indicate that they evolved from a single species or a group of closely related species. After invad-

ing this continent, they apparently were forced southward, probably because North America became too cold for their existence. In South America, they began to explode, finally forming a tertiary focus of distribution, extending their range north into the United States, south into Argentina, and onto the Antilles. However, they have retained the characteristic maculation which distinguishes them from all other Limenitines.

The subgenus *Limenitis* in the American Hemisphere is interesting. It ranges from Vera Cruz, Mexico, north along the East Coast, possibly expanding in northern Mexico, throughout the United States into southern Canada. The northern limit of its range lies approximately near the 50th parallel, but extends further north along the eastern side of the Rocky Mountains into the Mackenzie Valley as far north as the 70th parallel. Additional data, not available in collections today, might perhaps extend this range a little. From this distribution, it can be seen that like its closest Eurasian relatives (i. e. *Limenitis populi*), they are most abundant in North Temperate regions. This distribution indicates that they reached this continent and became established prior to the last glaciation. The North American fauna is very limited in species in contrast to the Old World. It can be assumed that they entered North America over the Alaskan bridge when ecological conditions were suitable. These conditions were a warmer climate than exists in that region today, along with the elevation of the bridge. Their southern distribution was, and apparently still is limited by tropical conditions. The fact that there are no *Limenitis* found either in Alaska, or the area west of the great divide north of 52°, would tend to preclude the possibility of this subgenus entering America since the last glaciation. Also, the North American species have become distinct from any of their Eurasian relatives to a degree that suggests a fairly long period of isolation. Their consubgeneric status with their Old World relatives cannot be disputed, although no interspecific relationships are apparent. Most groups of butterflies which have entered North America since the last glaciation, are holarctic in distribution, and many species are continuous around the globe. This can be seen in the circumpolar distribution of *Erebia theano, Papilio machaon* and *Boloria frigga*, which have become differentiated into subspecies, but have had no isolating factors which would stimulate speciation.

Neptis represents a specialization of the tropical forms of the genus *Limenitis*. It probably first arose in Asia, where the greatest number of species exist, and has spread to the East Indies and northern Australia, eastern Europe, and reinvaded Africa.

If the *Euthalia* line is considered, again the most primitive genus *Catuna*, is restricted to Africa, along with *Hamanumida, Euphaedra* and *Euryphaedra*. *Euphaedra* represents the culmination of development in that continent, with an extremely large number of species. Again Asia is invaded by this line of *Limenitines*, resulting in the large genus *Euthalia*. These have been restricted to tropical regions, however, and have not invaded the New World, nor the temperate zones of the Old World. Their close affinity to *Euphaedra*, coupled with the fact that they are not found in South America with *Adelpha*, might

indicate that they have invaded Asia in relatively recent times. They have, however, extended their range beyond Weber's line, which *Limenitis* has not been able to do.

Briefly summarizing the phylogeny of the *Limenitini*, the most primitive species are probably best represented by *Parthenos*, an offshoot from the base of the main Limenitine line. *Harma*, an African genus found in the tropics, is probably in the direct line of descent of the tribe. From this genus, two branches develop: the *Limenitis* line and the *Euthalia* line. The *Limenitis* line includes *Pseudacraea, Lebadea, Limenitis* and *Neptis*. The first is restricted to Africa; *Lebadea* is found in southeastern Asia; *Limenitis* has spread throughout the world with the exception of Africa and Australasia; and *Neptis* has spread throughout the Old World, reinvading Africa. The *Euthalia* line contains *Catuna; Hamanumida; Euphaedra; Euryphaedra;* and *Euthalia*. Of these, all are restricted to Africa with the exception of *Euthalia* which has invaded southern Asia. All genera are restricted to the tropics with the exception of a few species belonging to the genera *Limenitis* and *Neptis*.

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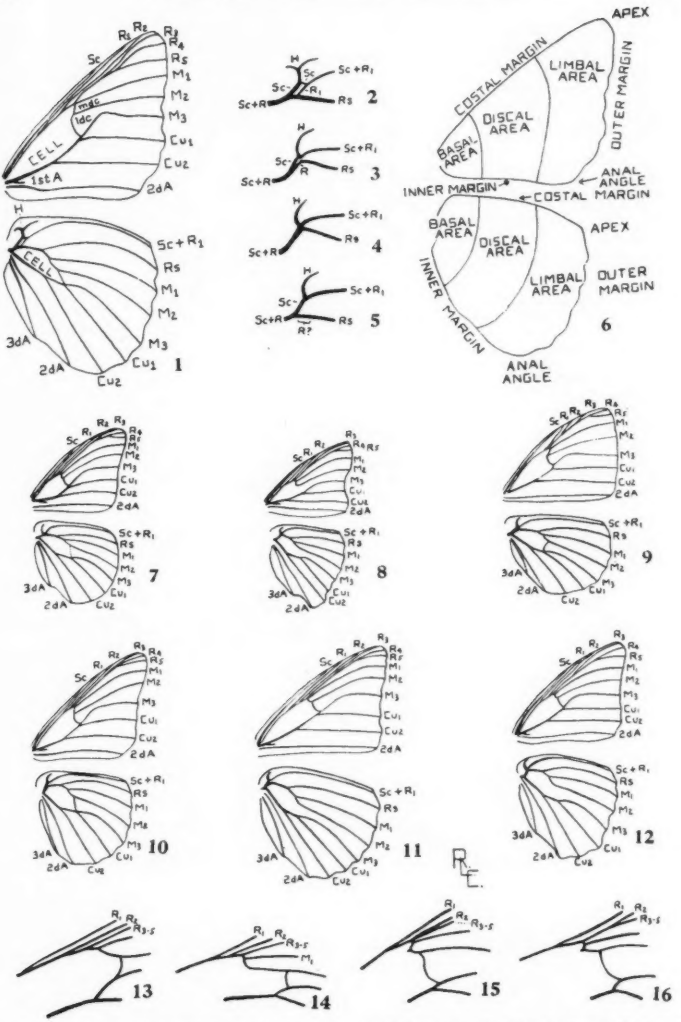
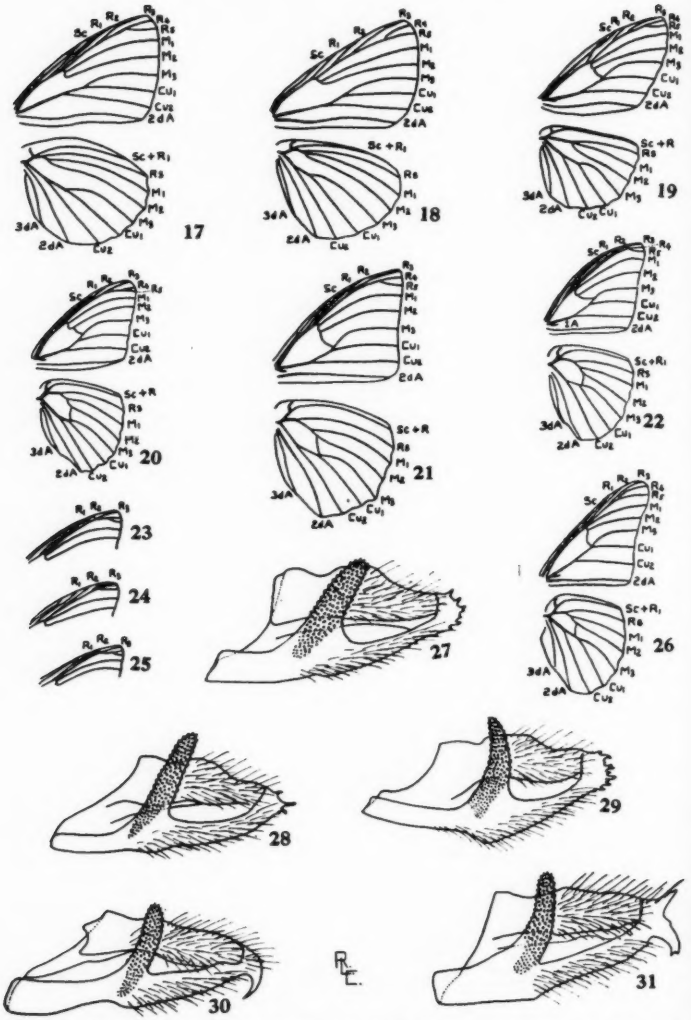
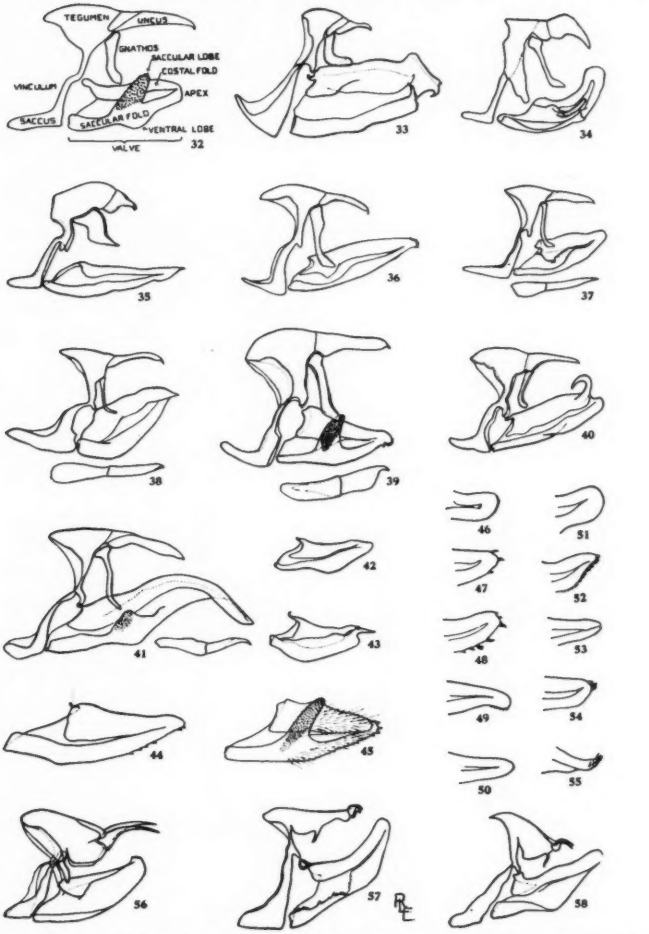


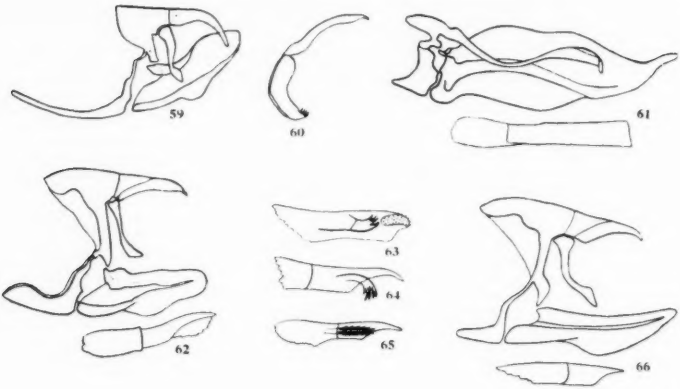
Figs. 1-16.—1. Venation of *Parthenos sylvia;* 2. Subcostal cell of hindwing; 3. Bases of Sc and R of hindwing approximate; 4. Bases of Sc and R of hindwing fused; 5. Bases of Sc and R of hindwing widely divergent; 6. Nomenclature of wing (diagrammatic); 7. Venation of *Harma caenis;* 8. Venation of *Harma kinuguana;* 9. Venation of *Pseudacraea coenobita;* 10. Venation of *Pseudacraea lucretia;* 11. Venation of *Limenitis populi;* 12. Venation of *Limenitis bredowii eulalia;* 13. Cell of primaries of *Limenitis procris;* 14. Cell of primaries of *Limenitis linoides;* 15. Cell of primaries of *Limenitis camilla;* 16. Cell of primaries of *Limenitis cottini.*

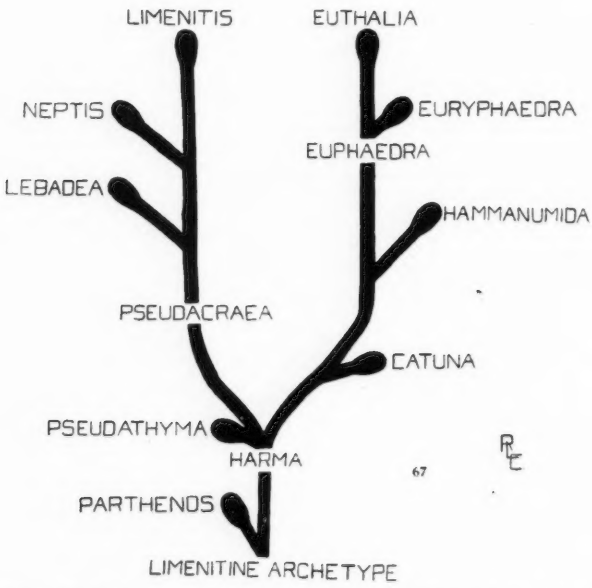


Figs. 17-31.—17. Venation of *Neptis hylas;* 18. Venation of *Neptis hordonia;* 19. Venation of *Catuna oberthuri;* 20. Venation of *Hamanumida daedalus;* 21. Venation of *Euthalia hardama;* 22. Venation of *Euphaedra neophron;* 23. Radial branching of *Hamanumida concordia;* 24. Radial branching of *Hamanumida opis;* 25. Radial branching of *Hamanumida nyassae;* 26. Venation of *Lebadea martha;* 27. Genitalic valve of *Limenitis arthemis arthemis;* 28. Genitalic valve of *Limenitis lorquini;* 29. Genitalic valve of *Limenitis weidemeyeri;* 30. Genitalic valve of *Limenitis archippus floridensis;* 31. Genitalic valve of *Limenitis archippus obsoleta.*



Figs. 32-58.—32. Terminology of male genitalia (diagrammatic); 33. Male genitalia of *Parthenos tigrina;* 34. Male genitalia of *Harma theobene;* 35. Male genitalia of *Harma caenis;* 36. Male genitalia of *Pseudacraea lucretia;* 37. Male genitalia of *Pseudacraea coenobita;* 38. Male genitalia of *Lebadea martha;* 39. Male genitalia of *Limenitis populi;* 40. Male genitalia of *Neptis hylas;* 41. Male genitalia of *Limenitis camilla;* 42. Genitalic valve of *Neptis hordonia;* 43. Genitalic valve of *Neptis agatha;* 44. Genitalic valve of *Limenitis serpa;* 45. Genitalic valve of *Limenitis arthemis arizonensis;* 46. Tip of valve of *Limenitis hellmani;* 47. Tip of valve of *Limenitis* (*Adelpha*) *corcyra;* 48. Tip of valve of *Limenitis* (*Adelpha*) *californica;* 49. Tip of valve of *Limenitis* (*Adelpha*) *lerna;* 50. Tip of valve of *Limenitis* (*Adelpha*) *gelania;* 51. Tip of valve of *Limenitis sulpitia;* 52. Tip of valve of *Limenitis oberthuri;* 53. Tip of valve of *Limenitis sibylla;* 54. Tip of valve of *Limenitis lymire;* 55. Tip of valve of *Limenitis cottini;* 56. Male genitalia of *Hamanumida daedalus;* 57. Male genitalia of *Hamanumida atossa;* 58. Male genitalia of *Hamanumida opis.*





Figs. 59-67.—59. Male genitalia of *Catuna oberthuri;* 60. Uncus and gnathos of *Euthalia palguna;* 61. Male genitalia of *Euthalia leucotaenia;* 62. Male genitalia of *Euthalia phantasiella;* 63. Aedeagus of *Euthalia teuta;* 64. Aedeagus of *Euthalia advena;* 65. Aedeagus of *Euthalia eutychius;* 66. Male genitalia of *Euthalia durga;* 67. Phylogenetic tree of the tribe Limenitini.

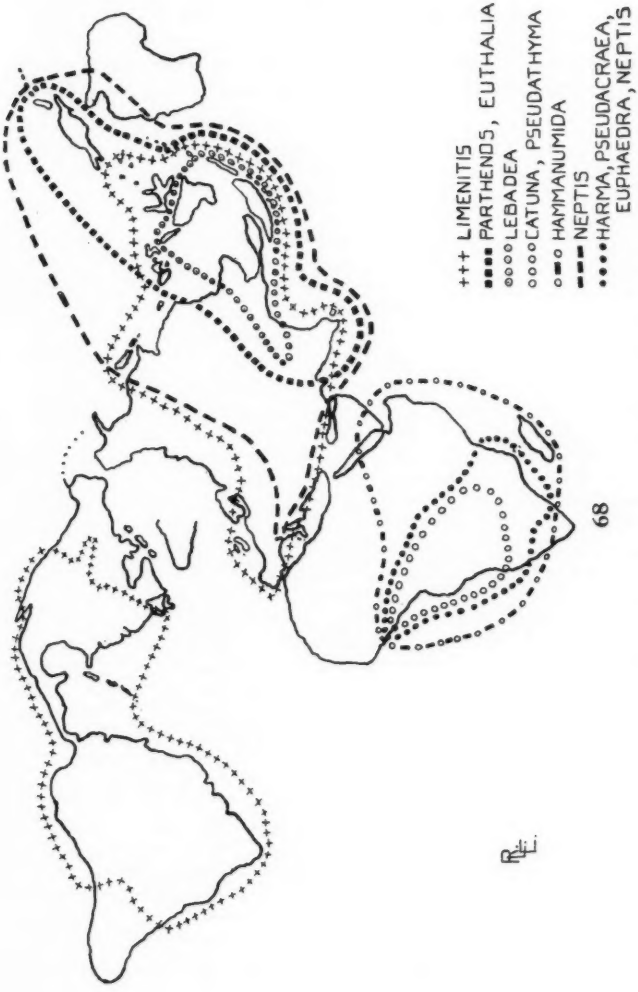


Fig. 68.—Distribution of the genera of the tribe Limenitini (polar projection).

New Species in the Genera, Anoplius, Pycnopompilus, and Streptosella, N. Gen.

(Hymenoptera: Psammocharidae) With Keys and Microphotographs of the Genitalia of the Males of these Genera and Agenioideus for North America and the Antilles.

R. R. Dreisbach
Midland, Michigan

In studying the genitalia of the tribe Psammocharini it was found that several species have genitalia that are almost alike but very different from those of any other genus. An inspection of the insects themselves shows that they do not fit any other genus and the genus *Streptosella* is erected to contain these three species.

Streptosella n. gen.

Small species with the appearance of the genus *Pompilinus;* head small, lenticular when seen from the side; ocelli small, and posterior orbits about two-thirds as wide as the eyes when seen from side; antennae short, slender, and first joint as long or longer than the third; pronotum relatively long when compared to the mesonotum, and hardly angulate; eyes extended only to the base of clypeus, but reach the vertex; propodeum with dorsal surface longer than the posterior surface, and with a shallow sulcus on dorsal surface which ends at the edge of declivity; no upright hair on propodeum; venation of wings somewhat varied, more so than any other genus although the genitalia are almost exactly alike; in two cases the third cubital cell is widely open on marginal vein, and in one of these cases the marginal cell is longer than its distance to wing tip and in the other case the marginal cell is shorter than its distance to wing tip; in the third case the third cubital cell is very strongly petiolate, with its cell small, and the marginal cell is only two-thirds as long as its distance to wing tip; in the two cases with the wide open third cubital cell, the insect has a slightly sericeous appearance, while in the other case the insect is entirely black with no appearance of sericeous; the front claws instead of being split as in *Pompilinus* or *Anopompilinus* have the two claws arising from the same base and are parallel with each other and do not angle away from each other at tips, with the outer ray about twice as long as the inner; the other two pair of claws have a small tooth at the apical third and the basal two-thirds of claw behind this tooth is very broad; last two joints of tarsi with no spines beneath them, and the fourth and fifth joints of posterior pair are of equal length; genitalia very characteristic, with twisted volsellae, hence the generic name; last ventrite with two short longitudinal ridges enclosing about one-third of ventral surface between them, extending from a short distance before base to beyond middle of segment; this is also characteristic of the genus; two of the species (those with wide cubital cell) are 6.8 mm. to 7.0 mm. long while the third one is much smaller, 5.0 mm. long. This genus

runs to couplet 39 in the writer's key (1) to the genera of Psammocharini, and is separated from the two genera of that couplet as follows (males only):

1. Marginal cell much shorter than its distance to wing tip and with third cubital cell not petiolate; volsellae and parapenial lobes are straight not twisted; aedeagus with sides straight and generally with glandular protuberances on the sides ..... *Anopompilinus* Dreisbach

1. If marginal cell is much shorter than its distance to wing tip then the third cubital cell is petiolate and the volsellae are twisted, and claws of fore legs are parallel 2

2. If marginal cell is much shorter than its distance to wing then third cubital cell is petiolate; volsellae narrow and twisted; aedeagus straight for whole length; fourth and fifth joints of posterior tarsi of aequal length; pronotum not angulate; last ventrite not expanding into wings at base; claws of fore legs parallel ..... *Streptosella* n. sp.

2. Marginal cell just about its distance from wing tip; third cubital cell not petiolate; volsellae very broad at tip; parapenial lobes thick and twisted above middle; fourth joint of posterior tarsi much shorter than fifth joint; pronotum angulate; last ventrite extending outward into wings at base; aedeagus much narrower in the middle than at tip; claws of fore legs split and farther apart at tip than at base ..... *Anoplochares* Banks

Genotype: Streptosella michiganensis Dreisbach.

KEY TO THE THREE SPECIES OF STREPTOSELLA*

1. Size small, overall length 5 mm, fore wing 4.0 mm, rear wing 3.30 mm; all black without any sericeous appearance; distance of marginal cell to wing tip one and one third its length; third cubital cell petiolate; no long upright hairs on front; no red on abdomen ..... *stricklandi* n. sp.

1. Size much larger, overall length over 6.8 mm, fore wing over 5.2 mm, rear wing over 4.0 mm; third cubital cell not petiolate; slight sericeous tinge to thorax and part of legs; long upright hairs over whole front 2

2. All of second and part of first and third tergites red; a barely noticeable sulcus on dorsal part of propodeum; marginal cell slightly longer than its distance to wing tip; last ventral segment widest at base ..... *albertensis* n. sp.

2. Only sides of first tergite, basal three fourths of second tergite, and basal one third of third tergites red, and this red only faint; sulcus on dorsal part of propodeum more evident; marginal cell as long as distance to wing tip; last ventral segment just as wide near middle as at base ..... *steyskali* n. sp.

Streptosella steyskali n. sp.

Holotype male.—Black except the sides of first tergite, and the basal half of second which are reddish; a great many long hairs over vertex and front, with shorter upright hair on clypeus, mandibles, mentum, posterior orbits, neck, fore coxae, and with even fewer, shorter ones on pronotum; a few closely appressed, slightly sericeous hair on thorax, coxae, trochanters, and more strongly sericeous on posterior part of propodeum; clypeus truncate in front

* Since this paper went to press the following paratypes have been received: *Streptosella albertensis* n. sp. Paratypes from Otsego Co. Mich., VII-23-49 R. R. Dreisbach (RRD), and *Anoplius banksi* n. sp. Mt. Monadnock, N. H., VI-21-41, R. C. Osburn (MCZ).

and practically straight when seen from the side; when seen from the side, the eyes extend from base of clypeus to vertex with not a trace of ocellar triangle visible above surface of eyes; the antennal fossae and a very short space behind it the only part of front visible above the surface of eyes; posterior orbits two-thirds the width of eyes; fore ocellus its diameter from the laterals and these as far apart as their distance to eye margins; no sulcus in front of fore ocellus; first antennal joint one and one half times as long as the third and fourth and ultimate joints, the latter three being subaequal; pronotum not angulate, almost transverse and relatively long when compared with the mesonotum; a shallow sulcus on dorsal surface of propodeum; propodeum somewhat arched from front to rear of dorsal surface so that the highest part is about the middle; wings slightly fumose all over but more strongly so at the tips, with a violaceous reflection in reflected light; third cubital cell not nearly sessile but one third as long on marginal vein as on the cubital vein, and just about as long on cubital vein as the second cubital cell; second cubital cell one and one half times as long on the marginal as the third; both recurrent veins received about the middle of their respective cubital cells; the basal vein considerably basad of the transverse in fore wings and in the rear wings the subdiscoidal slightly beyond the cubitus; marginal cell slightly shorter than its distance to wing tip; no spines on anterior femur except at tip, second and third pair with a few very small ones on dorsal surface; spines only at tip of fore tibiae except one about middle of ventral surface; second and third pair of tibiae with numerous spines; tarsal joints with only the basal joint with spines on dorsal surface; second and third tarsal joints with spines only on ventral surface and these very small; no spines on ventral surface of fourth and fifth tarsal joints, except very tiny ones which are closely appressed; fourth and fifth (without the claws) tarsal joint of posterior legs of equal length; longer spine of posterior tibiae about one half as long as its metatarsal joint.

The genitalia is almost exactly like that of the other two species, except the parameres are slightly broader at the upper half and the volsellae are slightly broader on basal half. Last ventrite nearer like that of *S. stricklandi* but differs in that the broadest width is just where it expands and then the edges curve inward so that the part just above the base becomes the narrowest part of segment, while in *stricklandi* the narrowest part is the tip.

Length: Head and thorax 3.30 mm; abdomen 3.50 mm; fore wing 5.95 mm; rear wing 4.0 mm; genitalia length 0.73 mm, width 0.53 mm; last ventrite length 0.93 mm, width 0.40 mm. (Figs. 1, 2).

Holotype male: Deerfield township, Lapeer Co., Mich., VII-4-37, Geo. Steyskal. (MZ).

Streptosella albertensis n. sp.

Holotype male.—Black except for the basal abdominal segments, which are red; first tergite with dorsal, basal three fourths, black, remainder red, second tergite dorsally and ventrally and the third on dorsal basal half also red; thorax, coxae, trochanters, femur and abdomen slightly sericeous, with the abdomen more strongly so than the rest of body; vertex and whole front with unusually long, upright hair with the neck just about as hairy; clypeus, mandibles, posterior orbits, fore coxae, pronotum, and propodeum with shorter,

less numerous, upright hair; clypeus truncate and hardly with any bulge when seen from the side; when seen from the side the eyes extend forward to the basal third or less of clypeus and they do not quite reach the top of vertex; posterior orbits slightly narrower than the eyes; when seen from in front the eyes are slightly closer to each other at clypeus than at vertex, and the ocellar triangle is slightly raised above rest of surface; anterior ocellus slightly more than its diameter from the laterals and these slightly closer together than their distance to eye margin; no line or sulcus on front; first antennal joint one half longer than the third or fourth, with a few upright hairs on this joint; pronotum hardly angulate; propodeum in a smooth curve with hardly any dorsal surface; wings brownish all over but slightly more so at tip; third cubital cell not nearly sessile, one third as long on marginal as the third and two thirds as long on marginal vein as on cubital vein; first recurrent vein meets the second cubital cell beyond the middle and the second recurrent meets the third cubital cell at middle; basal vein of fore wings basad of the transverse vein while the veins of rear wing are interstitial; marginal cell longer than its distance to wing tip; no hair bands on ventral segments; no spines on fore femur and only one small one dorsal surface of middle not quite at apical third, no spines on posterior femur except at tip; one spine on fore tibiae on ventral surface besides those at tip; last two pair of tibiae well spined; small spines on dorsal basal tarsal joints only with a few on the ventral surface, except the last joint which is free of ventral spines; longer spur of posterior tibiae two thirds as long as its metatarsal joint; the fore claws broken off the middle and posterior pair like those of *S. stricklandi;* last ventrite with two parallel ridges about the middle third of segment with the space between them about one fourth the width of segment; the sides of tip gradually becoming wider for one third of its length (without spur) and then suddenly broadening out and then the sides running forward almost parallel; in contrast to this *stricklandi* extends forward at an angle to beyond middle (this is the broadest part) and then continuing on in parallel lones, while in former the broadest width is at base of segment; this ventrite also has a wide section on broadest part of base just inside of edge free of hair and translucent, while *stricklandi* has only a very short narrow section just at beginning of widest part of segment; genitalia almost identical with *stricklandi* but last ventrite different as noted above.

Length: Head and thorax 3.65 mm, abdomen 3.40 mm, fore wing 5.30 mm, rear wing 4.0 mm, genitalia length 0.73 mm, width 0.60 mm, last ventrite length 0.66 mm, width 0.53 mm. Figs. 3, 4.

Holotype male: Bilby Alberta, VII-20-24, O. Bryant. (MCZ)

This species has the coloration of *Pompilinus hageni* Banks which was described in the female sex only, but the characters do not fit this specimen. In his description of *hageni* Banks states that the lateral ocelli are as close to each other as their distance to eye margin, pronotum angulate, marginal cell twice its length from wing tip, and third cubital cell subtriangular. None of these apply to this species as the ocelli are nearer each other than to eye margin, pronotum is not angulate, marginal cell is longer than its distance to wing tip, and third cubital cell is not subtriangular.

Streptosella stricklandi n. sp.

Holotype male.—Completely black, except for the indication of red on basal three-fourths of second tergite and basal third of third tergite; this red not so strong as in *S. albertensis;* only a very few long hairs on vertex, a few much shorter ones on fore part of posterior orbits and a few back of eyes, none anywhere else; no sericeous hairs anywhere and an entirely different aspect than in the other two species; when seen from the side, the basal three-fourths of clypeus is flat, but then it turns downward so that tip is much lower than basal surface; tip of clypeus truncate; when seen from the side, the front gradually rises from vertex to antennal fossae so that this part is slightly above eye surface; the eyes extend to base of clypeus only and they just barely reach top of vertex; posterior orbits very narrow, only one-third width of eye; when seen from in front, the vertex rises gradually from eye to ocellar triangle and this triangle above the rest of vertex; ocelli very small, fore ocellus about twice its diameter from the laterals and these slightly nearer each other than their distance to eye margin; first joint of antennae slightly longer than the third or fourth or ultimate joint, the latter three being subaequal in length, with the penultimate being slightly shorter than the utlimate; no upright hair on first joint; pronotum not angulate; two-thirds of length of propodeum as dorsal surface and then turning downward at an obtuse angle; propodeum with a short sulcus on dorsal surface; wings slightly yellowish, more so at tip; third cubital cell petiolate and very small, with about the same length on cubital vein as the second cell; second cubital cell one-half as long on marginal vein as on cubital vein; first recurrent vein meets the second cubital cell at middle and the second recurrent vein meets the third cubital cell beyond the middle; in fore wings the basal vein basad of the transverse vein and in rear wings the subdiscoidal is much beyond the cubitus; marginal cell with its distance to wing tip equal to one and one-half times its length; no spines on femur or fore tibiae except at tips; middle and posterior tibiae with numerous spines, basal tarsal joints with a few small spines, but the other joints practically devoid of spines on dorsal surface, with a row each side on ventral surface, of second and third joints; fourth and fifth joints of tarsi with no spines; fourth and fifth (without claws) joints subaequal in length.

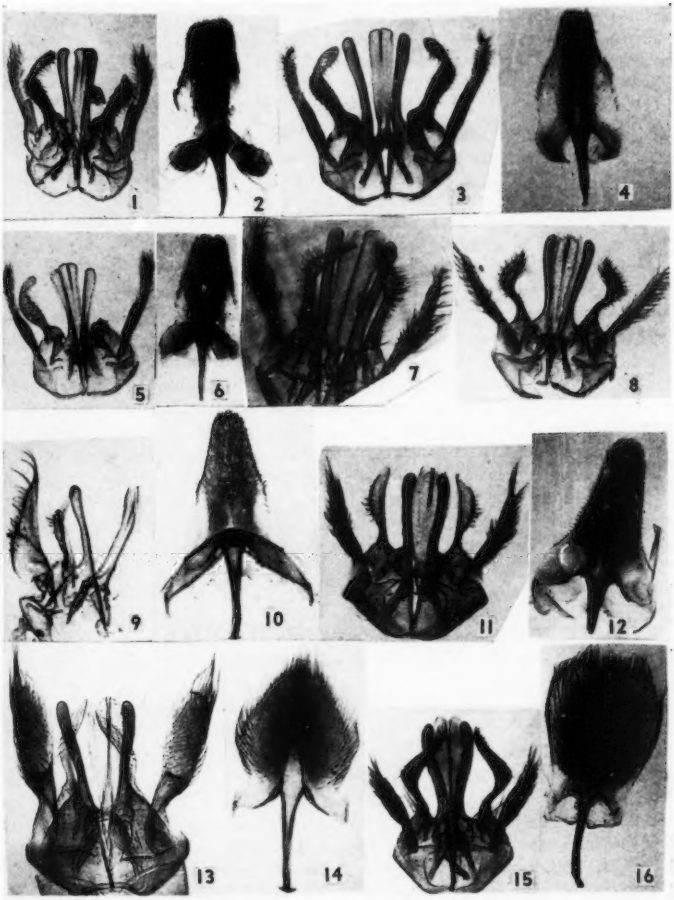
Length: Head and thorax 2.32 mm, abdomen 2.60 mm, fore wing 4.0 mm, rear wing 3.30 mm, genitalia length 0.66 mm, width 0.53 mm, last ventrite length 0.80 mm, width 0.34 mm. Figs. 5, 6.

Holotype male: Toticut, Alberta, V-22-23, E. H. Strickland. (MCZ)

For comparison of this species with *albertensis* see that species.

Genus ANOPLIUS Dufour

This genus is characterized in the female by the absence of a tarsal comb on fore legs, long stiff hairs sloping backward on the last tergite, vertex not raised above the surface of eyes, angulate pronotum, and the marginal cell large and generally longer than its distance to wing tip. The male is distinguished by the split claws of all the legs, last ventrite with a slight ridge or roof-shaped, and the ocellar triangle generally slightly elevated above the rest of vertex, in addition to the characters in the female that are applicable to the male, and the genitalia and last ventrite are very similar throughout



Figs. 1-16.—1. *Streptosella steyskali* n. sp., genitalia ×35; 2. *S. steyskali* n. sp., last ventrite ×38; 3. *S. albertensis* n. sp., genitalia ×38; 4. *S. albertensis* n. sp., last ventrite ×49; 5. *S. stricklandi* n. sp., genitalia ×31; 6. *S. stricklandi* n. sp., last ventrite ×35; 7. *Anoplius aenopurpureus* (Cresson), genitalia ×?; 8. *A. simulans* (Cresson), genitalia ×?; 9. *A. baalis* n. sp., genitalia ×42; 10. *A. basalis* n. sp., last ventrite ×37; 11. *A. elongatus* n. sp., genitalia ×42; 12. *E. elongatus* n. sp., last ventrite ×44; 13. *A. banksi* n. sp., genitalia ×42; 14. *A. banksi* n. sp., last ventrite ×37; 15. *A. ithica* Banks, genitalia ×45; 16. *A. ithica* Banks, last ventrite ×40.

the genus and different from any other genus, as can best be seen by inspecting the photomicrographs.

Anoplius Dufour, Ann. Soc. Ent. France. 2, 1834, p. 484. (o.d. Genotype. *Pompilus nigerrimus* Scop.). *Anoplius* Banks, Joun. N. Y. Ent. Soc. 19, 1911, p. 224, (key). *Anoplius* Banks, Bull. Mus. Comp. Zool. 61, 1917, p. 107, (key). *Anoplius* Banks, Bull. Mus. Comp. Zool. 63, 1919, p. 231, (key). *Anoplius* Brimley, Journ. Elish. Mitch. Sci. Soc. 52, 1936, p. 123, (key). *Anoplius* Banks, Can. Ent. 71, 1939, p. 228 (comparisons, key). *Anoplius* Bradley, Notulae Naturae, Acad. Nat. Sci. Phila. 145, 1944, *Anoplius* Dreisbach, Mich. Acad. Sci. Arts & Letters 32, 1948, pp. 245, 247, (key, genera).

The following six species and one variety are considered as new and are described as such.

Anoplius elongatus n. sp.

Holotype male.—Completely black; a few long hairs on vertex, mandibles, posterior orbits, neck and a few on pronotum; clypeus truncate and without a bulge when seen from the side; the front slightly above surface of eyes, when seen from the side; the eyes extending to about middle of clypeus and they do not quite reach the vertex; the vertex when seen from in front, almost straight across but curving up to middle which is the highest part; a very faint sulcus from fore ocellus to antennal fossae; fore ocellus about its diameter from the laterals and these one-half as far apart as their distance to eye margin; first joint of antennae slightly longer than the third which is subaequal to the fourth; pronotum slightly anguulate; the whole thorax, as well as head and legs covered with short closely appressed whitish hair, not sericeous except each side of antennal fossae and a transverse line at anterior edge of face; abdominal hair shorter, less numerous and brownish; propodeum short and almost whole surface in a smooth curve from base to tip; third cubital cell very slightly petiolate; first intercubital vein curving backward so that it is almost parallel in the latter half to the cubital vein, thus making the second cubital somewhat elongate and slightly pointed at each end; first recurrent vein received by the second cubital cell beyond the middle and the second recurrent by the third cubital cell in the middle; in the fore wings the basal and transverse veins are interstitial, while in the rear wings the subdiscoidal is much beyond the cubitus; the fourth and fifth ventral segments have a very strong brush of hairs in two rows each side along the edge of segments which are rather long, while the surface between these two rows is much shorter, hardly visible from the side, almost flat and inclined backward; femur without spines except at tip; fore tibiae without spines except on ventral surface and at tip, the other two pair rather heavily spined; tarsi spined at tip and on ventral surface, the spines on apical segments so closely appressed as to appear without spines; longer spur of posterior tibiae two-thirds as long as its metatarsal joint.

Length: Head and thorax 2.65 mm, abdomen 3.0 mm, fore wing 4.64 mm, rear wing 3.30 mm, genitalia length 0.66 mm, width 0.66 mm, last ventrite length 0.73 mm, width 0.53 mm. Figs. 11, 12.

Holotype male: Pelican Lake, Nisswa, Minn., VII-30-19, L. Brunner (Neb.)

This species is named for the elongate volsellae which have a much longer part of the length of the same breadth. The last ventrite is characterized by the fact that the apical three-fourths is almost parallel sided, and no other species has so much of the narrow apical part after the widened basal section.

Anoplius hispidulus n. sp.

Holotype male.—Completely black, with very fine, closely appressed whitish hair on clypeus, face, thorax, first tergite, coxae and part of femur, with those on face and clypeus sericeous in reflected light; a few long upright hairs on vertex, front, clypeus, mandibles, posterior orbits, neck propodeum and a few shorter ones on pronotum, as well as dense hair bands on the fourth and fifth tergites, and very long hispid hair on last ventrite; abdomen, except first tergite, covered with appressed, brownish hair longer than that on thorax and with those on last two tergites much longer and directed backward; the ventral basal surface of seventh tergite absolutely devoid of hair, polished, shining; the hair on face silvery in reflected light; clypeus truncate and with a slight bulge, when seen from the side; only a very small amount of the surface just back of antennal fossae above the surface of the eyes, when seen from the side and ocellar triangle not raised above eyes; posterior orbits broadest at the upper third and there about two-thirds as wide as eyes; a slight depression just behind antennal fossae and just in front of fore ocellus but no sulcus or line connecting them; anterior ocellus less than its diameter from the laterals, and these twice as far apart as the distance between them and the eye margin; a few upright hairs on first antennal joint with dense, closely appressed hairs, and those in front silvery; first, third, fourth and apical joints subaequal in length with the penultimate slightly shorter; pronotum angulate; propodeum in a smooth curve from base to tip; wings slightly fuliguinous, with the tips darker and with a milky white, and violaceous reflection; third cubital cell sessile, and slightly longer on cubitus than the second cell; second cubital cell slightly longer on the cubitus than on the marginal vein; both recurrent veins received beyond the middle of their respective cells; in fore wings the basal and transverse veins are interstitial, but in the rear wings the subcoidal is much beyond the cubitus; the hair bands on ventrals have short hair that is just plainly visible when seen from the side, and when seen from below these two longitudinal hair bands appear as ridges with the surface between them appearing as hollow, with practically no hair in this portion; last ventral segment is roof-shaped when seen from the side; last tergite with long hairs depressed and directed backward, femur without spines except at tip, for tibiae with one spine about the middle on ventral surface and a large one on outside just before the tip, as well as the ones at tip; middle and posterior tibiae well spined on all sides; basitarsi with a few spines on dorsal surface, but these absent on other joints on the posterior surface; longer spur of posterior tibiae four-fifths as long as its metatarsal joint; parameres of genitalia longer in comparison to the rest of genitalia than those of any other species, as they extend well beyond the rest of genitalia. The volsellae are also distinguished by the fact that the upper half are bare of hair. The last ventrite is distinguished by its long hispid hair extending downward from the segment. Named for the long hispid hairs on last ventrite.

Length: Head and thorax 3.40 mm, abdomen 4.33 mm, fore wing 7.0 mm, rear wing 5.3 mm, genitalia length 1.0 mm, width 0.67 mm, last ventrite length 1.26 mm, width 0.66 mm. Figs. 25, 26.

Holotype male: Algonquin, Ill., VIII-10-95, No. 137 (INHS).

Paratype: Oscoda Co., Mich., R. R. Dreisbach (RRD) VI-10-47.

Anoplius basalis n. sp.

Holotype male.—Completely black, with most of thorax, coxae, femur, and basal abdominal tergites covered with very fine, closely appressed, whitish hair, showing up as slightly sericeous on apex of propodeum, first two tergites and coxae; long upright hair on vertex, front, face, clypeus, mandibles, posterior orbits, under head, neck, and with a few shorter ones on pronotum, propodeum and fore coxae; a very evident hair band on tergites four and five, with only a few long hairs in a row each side, while in the middle of these are much shorter, much more closely spaced, appressed, backward directed hairs, while the third ventrite has about six to eight long upright hairs about the middle of segment; clypeus truncate in front and with a slight bulge, when seen from the side; when seen from the side the nearer lateral ocellus is seen above the eye surface, but the vertex and rear half of front even with the eye, the front rising in a smooth curve to the antennal fossae so that the fore half of front is above the eye surface and is highest at the antennal fossae; eyes reaching only to about basal third of clypeus, and posterior orbits widest at upper third, and only about one-half as wide as eyes; when seen from in front the ocellar triangle stands above the rest of vertex; a faint line between the fore ocellus and antennal fossae; anterior ocellus about its diameter from the laterals and these two-thirds as far apart as their distance to eye margin; basal joint of antennae without any upright hair but with dense closely appressed hair and these silvery in front; first joint of antennae about as long as fourth but slightly shorter than third, the last joint slightly longer than the penultimate; pronotum in a smooth curve, without angulation; propodeum in a smooth curve from base to tip, no horizontal basal portion; third cubital cell sessile, and the two recurrent veins received by their respective cubital cells beyond the middle; second and third cubital cells of equal length on the cubitus and the second four-fifths as long on marginal vein as on the cubitus; in the fore wings the basal vein is strongly basad of the transverse, and in the rear wings the subdiscoidal arises much beyond the cubitus; wings slightly brownish all over but more strongly so at the tips; no spines on femur or fore tibiae except at tip; last two pairs of tibiae with very few spines; tarsal joint with no spines above except at tip, and those beneath closely appressed for the most part; longer spur of posterior tibiae about three-fourth as long as its metatarsal joint. The basal half of parameres of genitalia is very broad, hence the name, and tapers gradually from the middle to a point at tip; the last ventral segment is different from that of any other species, in that from a broad obtuse tip it gradually widens to about the middle where it expands suddenly and again gradually enlarges to the base.

Length: Head and thorax 3.40 mm, abdomen 2.90 mm, fore wing 3.30 mm, rear wing 5.0 mm, genitalia length 0.66 mm, width 0.5 mm, last ventrite length 1.00 mm, width 0.35 mm. Figs. 9, 10.

Holotype male: Rutland, Vt., VIII-15-16, Chittenden (MCZ).
Paratype: Nerepsis, Neb., VIII-20-? A. G. Levitt (Neb.)

The measurements of paratype practically the same as those of holotype.

Anoplius subtarsatus n. sp.

Holotype male.—Completely black; upright hair on head, clypeus, mandibles, fore coxae, pronotum, propodeum, and dense heavy hair bands on

fourth and fifth ventrites; very little, closely appresser hair anywhere except over most of abdomen, much longer over the apical part, long and extending backward on last tergite and last ventrite; the hair bands with very long, dense hair, the longest and thickest on apical half of ventrites four and five, so that they appear as two heavy patches slightly separated with sparser, shorter hair between, when seen from the side; when seen from below, the hair is well distributed across the segments; clypeus slightly arched, when seen from the side and truncate in front with a rather wide smooth apical margin; when seen from the side the eyes extend from base of clypeus to top of vertex, but the nearer ocellus is visible above the surface, as well as the front from the middle to antennal fossae; posterior orbits of about equal width throughout and one-half as wide as eyes; fore ocellus larger than the laterals and its diameter from them, with the lateral ones as far apart as their distance to eye margin; a slight depression in front of fore ocellus and a definite line to fossae; first antennal joint with long upright hair as well as depressed hair, slightly shorter than the third or fourth, the latter of equal length; the tiny bristles on first three joints black, but whitish beyond these joints; pronotum strongly angulate, and propodeum with a long horizontal dorsal surface, this surface three-fourths of whole length; wings deep brown and hardly any darker at tip; third cubital cell widely open on marginal vein, and as long on marginal vein as the second cubital cell, these two cells of about equal length on the cubitus; first recurrent vein meets the second cubital cell at spical third, while the second recurrent meets the third cubital beyond the middle; basal vein in fore wings basad of the transverse vein and in rear wings the subdiscoidal is almost interstitial with the cubitus; legs similar to preceding species; longer spur of hind tibiae four-fifths the length of its metatarsal joint; genitalia somewhat similar to that of tarsatus but the volsellae are longer, wider, and flatter, not somewhat round as in the latter species, and the hair on volsellae are fine cobwebby and not as stiff as in that species; last ventrite is also similar to *tarsatus* but the sides extend forward in a straight line from the tipe, while in *tarsatus* they curve outward a short distance from tip.

Length: Head and thorax 4.33 mm, abdomen 4.5 mm, fore wing 6.6 mm, rear wing 5.3 mm, genitalia length 1.20 mm, width 0.66 mm, last ventrite length 1.19 mm (tip to broken point of spur), width 0.79 mm. Figs. 18, 22.

Holotype male: Raleigh, N. C., V-9-40, D. L. Wray (N. C.).

Paratype: Stamford, Conn., VII-25-47, B. R. T. Lab. (BRT).

Measurements of paratype: Head and thorax 4.63 mm, abdomen 4.6 mm, wings same as type.

This seems to be the eastern counterpart of the Western *A. tarsatus*.

Anoplius banksi n. sp.

Holotype male.—Completely black; upright hair on head, clypeus, mandibles, posterior orbits, coxae, pronotum, and on fourth, fifth and sixth ventrites; only a very few upright hairs on ventrite four, with a greater number on ventrite five, and with considerably more on ventrite six, but still hardly hair bands in the accepted sense; these indicated hair bands longitudinal and on about the middle of segment, that on six appearing or accentuating a low longitudinal ridge on center of ventrite; head, thorax, legs and abdomen cover-

ed with fine, closely appressed hair; these appressed hairs on face and sides of antennal fossae to just above the fossae silvery; the appressed hair on coxae, thorax, and first abdominal tergite also slightly silvery but less so than on face; the appressed abdominal hair much longer and heavier and increasing in length to the apex, the last two or three tergites with long, back-directed hair with those on last tergite largest and projecting beyond tip; clypeus truncate with a smooth edge, slightly bulged, when seen from the side; the eyes extended from base of clypeus to just below top of vertex; posterior orbits widest in upper third and there one-half as wide as eyes; only antennal fossae and a very short length of front behind it extending above surface of eyes; when seen from in front, the ocellar triangle is raised slightly above the vertex and the eyes approach each other at base of clypeus; anterior ocellus less than its diameter from the laterals and these with the distance between them about two-thirds of their distance from the eyes; a depression on front of fore ocellus with a line extending forward for a short distance; first joint of antennae covered with short stiff hair, subaequal in length to joint three, the ultimate joint and the fourth of equal length; pronotum strongly angulate, propodeum without any flat horizontal surface but sloping downward from the base to apical one-third where the slope becomes steeper; wings fumate all over but more so at tip, with a milky, violaceous reflection; third cubital cell open on the marginal vein by about two times the width of a vein; this cell slightly longer on cubitus than the second; second cubital cell two-sevenths as long on marginal vein as on cubitus; first recurrent vein meets the second cubital cell at middle, while the second recurrent vein meets the third cubital cell at apical third; distance from marginal cell to wing tip three-fourths the length of cell; basal vein in fore wing strongly basad of the transverse vein and in rear wings the subdiscoidal vein is a considerable distance beyond the cubitus; femur with a few tiny spines on dorsal surface; fore tibiae with one large spine on ventral surface and a few very small ones besides the ones at tip; last two pair of tibiae well spined with large spines; only the first tarsal joint with dorsal spines and the ventral surface with mostly appressed spines; fore claws split and rays nearly parallel, but the outer ray is slightly curved on length opposite inner ray; last two pair with rays more nearly equal in length; genitalia with parameres very broad and heavy, and longer than the rest of genitalia; this species not to be confused with any other species by virtue of these heavy parameres; volsellae with broadest part very long; last ventrite slightly roof-shaped with very long hairs over roof shaped ridge as well as very long hairs on sides and tip; this ovate, pointed, and the long haired ventrite is also characteristic.

Length: Head and thorax 3.6 mm, abdomen 3.8 mm, fore wing 6.3 mm, rear wing 4.7 mm, genitalia length 0.80 mm, width 0.60 mm, last ventrite length 0.93 mm, width 0.51 mm. Figs. 13, 14.

Holotype male: Midland Co., Mich., VI-22-46, R. R. Dreisbach (MCZ).

Paratypes.—MIDLAND Co., Mich., VI-29-40, VIII-22-42, R. R. Dreisbach (RRD); OSCEOLA Co., Mich. (2) VII-7-47, R. R. D. (RRD); OTSEGO Co., Mich., VI-6-47, R. R. D. (RRD); CHEBOYGAN Co., Mich., VII-23-47, R. R. D. (RRD); LAKE Co., Mich., VII-12-47, R. R. D. (RRD); ISABELLA Co., Mich., VII-24-48, R. R. D. (RRD); KAKASKA Co., Mich., VII-8-38, IV-12-39, R. R. D. (RRD); EATON Co., Mich., (2) V-30-42, R. R. D. (RRD); GRATIOT Co., Mich., VI-13-42, R. R. D.

(RRD); MECOSTA Co., Mich., VIII-12-44, R. R. D. (RRD); LUCE Co., Mich., VII-5-46, R. R. D. (RRD); DELTA Co., Mich., VII-4-47, R. R. D. (RRD); GLADWIN Co., Mich., VII-29-39, R. R. D. (RRD); MONTCALM Co., Mich. (2), VI-12-42, R. R. D. (RRD); LAPEER Co., V-27-39, R. R. D. (RRD).

Pinecrest, Tuolumne Co., Cal., VII-17-48, P. H. Arnaud, Jr. (RRD); Colebrook, Conn., VIII-19-18 (4), W. M. Wheeler, (MCZ); Orr's Island, Me., VIII-25-07, (MCZ); Medonak, Me., VI-15-28 (MCZ); Rutland, Vt. (5), VIII-15-16, Chittenden (MCZ); Lincoln Co., Me., VII-9-10, D. J. Borror (MCZ); Holliston, Mass., VIII-21, VI-16, VI-3, N. Banks (MCZ); Canada No. 2051, C. F. Baker (MCZ); Kearney, Ont., X-6-09, M. C. VanDUZEE (MCZ); New England, Percy Gardiner (MCZ); Hamilton, N. Y. (2) VI-28-32; Holliston, Mass., VII-1895, F. H. Sprague, Glen House, N. H., VIII-7-14, (all MCZ); Cold Springs Harbor, N. Y., C. T. Brues (MCZ); Nantucket, Mass., C. W. Johnson (MCZ); Stacyville, Me., VI-24-00, Lercy Gardiner (MCZ); Nelson, N. H., VII-15-07 (USNH); Hampton, N. H., VI-8-09 (USNM); Door Co., Wis., VI-19-30, M. H. Doner (Wis.); Ute Creek, Colo., 9000', L. Bruner (Neb.); Wabamen, Alberta, VI-13-36, E. H. Strickland (Alta.).

This list includes 52 paratypes from the states of Me., N. H., Vt., Mass., Conn., N. Y., Mich., Wis., Colo., Calif., Ontario and Alberta, Canada. There are Michigan specimens from 15 counties. From the above records it is seen that this species is distributed across the whole northern section of the Continent. The paratypes for the most part are very uniform in size, with the holotype being about the largest, and the smallest has the head and thorax 2.65 mm long, the abdomen 3.3 mm, fore wing 4.6 mm, and the rear wing 3.4 mm.

Anoplius imbellis var. major n. var.

Figs. 20, 24

Holotype male.—Completely black, with no trace of sericeous hair; upright hair on head, clypeus, mentum, mandibles, posterior orbits, fore coxae, neck, pronotum, propodeum, and two dense hair bands on the fourth and fifth ventrites, and a very few long upright hairs on ventrite three; hair bands short in length covering only about the apical half of the segments and when in normal position almost touching on the two ventrites; the hair on these bands longer on the sides of segment and becoming shorter as they approach the middle of segment where they are the shortest; when seen from the sides the clypeus is slightly bulged in center, and the eyes do not quite reach the vertex, the nearer lateral ocellus just visible above the surface as well as a short length of front just behind antennal fossae; fore ocellus its diameter from the laterals and these three-fourths as far apart as their distance to eye margin; no line on front; first segment of antennae three-fourths as long as the third, and the latter subaequal to the fourth; pronotum angulate, propodeum sloping slightly for the basal three-fourths of its length, and then more strongly; wings brownish, more so at the tip; third cubital cell triangular, about twice the width of a vein between its sides on the marginal vein; the second and third cubital cells are about of equal length on the cubitus and the second cell is about five-eighths as long on the marginal vein as on the cubitus; marginal cell slightly longer than its distance to wing tip; basal vein in fore wings basad of the transverse vein and in the rear wings the subdiscoidal vein is beyond the cubitus; legs similar to the other species, claws of the latter two pair of legs with the inner ray smaller and narrower than those of fore legs;

longer spur of posterior tibiae about two-thirds as long as its metatarsal joint; last ventrite and genitalia like the species.

Length: Head and thorax 4.33 mm, abdomen 4.6 mm, fore wing 6.62 mm, rear wing 4.7 mm, genitalia length 0.66 mm, width 0.5 mm, last ventrite length 0.93 mm, width 0.6 mm.

Holotype male: Falls Church, Va., VI-29, N. Banks (MCZ).

The genitalia and last ventrite are exactly like those of the species, even in size, but the insect's itself is fifty per cent larger than the species in size, and the lateral ocelli are three-fourths as far apart as their distance to eye margin, while in *imbellis* they are only one-half the the distance apart as this distance, and there is no line on front. The first segment of antennae in *imbellis* is just about as long as the third, while in the variety the first joint is only three-fourths as long. Then too the distribution is quite different, although there are many instances of species with this distribution.

ANOPLIUS AENOPURPUREUS (Fox)

Pompilus aenopurpureus Fox, Trans. Amer. Ent. Soc., 18, 1891, p. 339. Male, female (o.d. Jamaica. Amer. Ent. Soc.).

A photo of the male genitalia of this species is shown, but one of the last ventrite is not available. This is distinguished in both sexes by the color, although there are two species from the west which have a bluish color, but not so strong and the geographical distribution should make them distinguishable, as this species is from the Antilles only, so far as known. Fig. 7.

ANOPLIUS APICATUS (Provancher)

Pompilus apicatus Provancher, Faun. Ent. Can. 2, 188, p. 621. Female (o.d. Can. Quebec Nat. Mus.).

This species was named from the female sex and the mal is unknown. The type is in the Quebec National Museum, and in a private communication Mr. Howard Evans writes that it is in good shape.

ANOPLIUS BERMUDENSIS Banks

Anoplius bermudensis Banks, Me. Soc. Cubana H.n. 12. 1937, p. 447. Female (o.d. Bermuda, M.C.Z.). *Anoplius bermudensis* Banks, Mem. Sociedad Cubana de Hist. Nat. 12, No. 4, 1938, p. 250. Female (o.d. Bermuda, M.C.Z.).

This species is known in the female sex only and is from Bermuda, as the name indicates.

ANOPLIUS DEPRESSIPES Banks

Anoplius depressipes Banks, Can. Ent. 51, 1919, p. 81. Female (o.d. N. Y., Ga.). *Psammochares (Anoplius) depressipes* Leonard, Cornell Uni. Agr. Exp. Stat. Mem. 101, 1928, p. 987 (N. Y.).

This species was described in the female and no male is known. It can be distinguished by means of the flattened fore tarsi with the outer edge angulate. I have seen this from Illinois as well as the type locality.

ANOPLIUS DOLLI Banks

Anoplius dolli Banks, Bull. Mus. Comp. Zool. 61, 1917, p. 104. Female (o.d. Texas, M.C.Z.).

This is another species known from the female only.

ANOPLIUS ILLINOENSIS (Robertson)

Pompilus illinoensis Robertson, Trans. Amer. Ent. Soc. 27, 1901, p. 202. Male, female (o.d. Carlinville, Ill.). *Psammochares* (*Anoplius*) *illinoiensis* Leonard, Cornell Uni. Agr. Exp. Stat. Mem. 101, 1928, p. 986 (N. Y.). *Anoplius illinoiensis* Brimley, Journ. Elish. Mitch. Sci. Soc. 52, 1936, p. 128. Male, female (pars. desc. key, N. C.).

The genitalia of this species is very characteristic and cannot be confused with any other species. The volsellae have the inner tip drawn out into a comparatively long point, with the upper half below the point very broad; the parameres have rather scattered hairs. The last ventrite approaches that of virginiensis, but broadens out more from middle to base, as can be seen from the figure. Hair bands on fourth and fifth sternite have long dense hair and when seen from the side these bands are continuous, wings are brown all over, more so at tip, and the face has silvery hair. An indication of hair bands on third and sixth ventrites, tips of hair white in reflected light.

Length: Head and thorax 3.63 mm, abdomen 3.60 mm, fore wing 6.3 mm, rear wing 5.1, genitalia length 1.0 mm, width 0.73 mm, last ventrite length 1.32 mm, width 0.53 mm. Figs. 19, 23.

I have seen this species from Ill., Mich., Conn., Fla., La., Mass., Neb., N. J., Ohio, Penna., S. D., and Wash. D. C.

ANOPLIUS IMBELLIS Banks

Anoplius imbellis Banks, Bull. Mus. Comp. Zool. 94, 1944, p. 169. Male, female (o.d. Ore., Ore. Agri. College para M.C.Z.).

The genitalia of this species is somewhat similar to that of *illinoensis* but the volsellae is of a different shape, not so pointed at the inner tip nor so broad on the apical half. The last ventrite is characteristic with the apical half with long bristles borne on the sides, with none whatever on the basal half, these stop abruptly as can be seen from the figure. It differs from the new variety described above in its much smaller size, as well as its distribution. Hair bands on ventral segments separated.

Length: Head and thorax 3.95 mm, abdomen 4.64 mm, fore wing 5.80 mm, rear wing 4.60 mm, genitalia length 0.73 mm, width 0.53 mm, last ventrite 1.00 mm, width 0.53 mm. Figs. 20, 24.

ANOPLIUS ITHICA (Banks)

Psammochares ithica Banks, Journ. N. Y. Ent. Soc. 19, 1911, p. 224. Female (o.d. N. Y., M. C. I.). *Psammochares* (*Anoplius*) *ithica* Leonard, Cornell Uni. Agr. Exp. Stat. Mem. 101, 1928, p. 987 (N. Y.). *Anopilus ithica* Brimley, Journ. Elish. Mitch. Sci. Soc. 52, 1936, p. 128. Female (pars. desc., key, N. C.).

This is another species that was described from the female. The male is known, but was never described and the description follows. Completely black, with the clypeus, face, posterior orbits, coxae, femur, and thorax

covered with very noticeable sericeous pubescence; numerous long hairs on head and neck with less numerous ones on pronotum and propodeum; when seen from the side, the clypeus has a slight curve from base to tip; a very small hair band on sixth ventral with just an indication of one on the fifth; the nearer ocellus is just visible when the head is seen from the side, but only very little of the front visible above the eye surface; posterior orbits very narrow, less than one-third as wide as eyes; when seen from in front the ocellar triangle is just visible above the vertex; fore ocellus its diameter from the laterals and these with the distance between them only half their distance to eye margin; no trace of line on the front; first and third joints of antennae suaequal in length; pronotum only slightly angulate and propodeum curves regularly from base to tip; wings slightly fuliginous, more so at tip; third cubital cell exceptionally wide on the marginal vein, as long as the second cell on this vein, and the third is one-half longer on the curbitis than the second; both recurrent veins meet their respective cells beyond the middle; basal vein almost interstitial with the transverse vein but slightly basad and the subdiscoidal vein in rear wings is slightly beyond the cubitus; legs with few spines; longer spur on posterior tibiae two-thirds as long as its metatarsal joint; third and fifth (without claws) joints of posterior legs about one-half longer than the fourth joint; all the claws toothed with the two posterior pair with shorter and sharper rays than the first pair; genitalia and last ventrite very characteristic; volsellae very narrow and long and bent at the basal third, parameres exceptionally short and rather stout, shorter than any of the other parts of genitalia; last ventral segment broadest at the tip, somewhat wedge shaped, and the only species with a last ventrite of this shape.

Length: Head and thorax 2.65 mm, abdomen 2.9 mm, fore wing 4.3 mm, rear wing 3.6 mm, genitalia length 0.66 mm, width 0.46 mm, last ventrite length 1.00 mm, width 0.53 mm. Figs. 15, 16.

I have seen this species from N. Y., Ohio and Mich.

ANOPLIUS LEPIDUS (Say)

Pompilinus lepidus Say, Boston Journ. Nat. Hist. 1, 1836, p. 303. Male (o.d. Mexico). *Pompilus lepidus* Cresson, Proc. Amer. Ent. Soc. 1, 1863, p. 317. (cat. Mexico). *Pompilus lepidus* Cresson, Trans. Amer. Eng. Soc. 1, 1867, p. 94. Male (Smith desc. "Mexico"). *Pompilinus lepidus* Cresson, Proc. Bost. Soc. Nat. Hist. 12, 1869, p. 367. Male, female (Mexico). *Anoplius lepidus* Bradley, Notulae Naturae, Acad. Nat. Sci. Phila. 145, 1944, p. 9. Male, female (pars. desc. new comb.).

A specimen labeled this species at the Philadelphia Academy of Science was a species of the genus *Psammochares*. Dr. Bradley (reference 5 above) says the type was probably lost, and he further states that a male determined by Cresson has hair brushes on sternites four and five. From the present study I am sure if the type was destroyed that this species will never be able to be distinguished, as it is necessary to inspect the genitalia and last ventrite, and Cresson's knowledge of these critical genera was very meager, since no genitalia studies were made.

ANOPLIUS PAPAGO Banks

Anoplius papago Banks, Can. Ent. 73, 1941, p. 120. Male (o.d. Ariz. M.C.Z.).

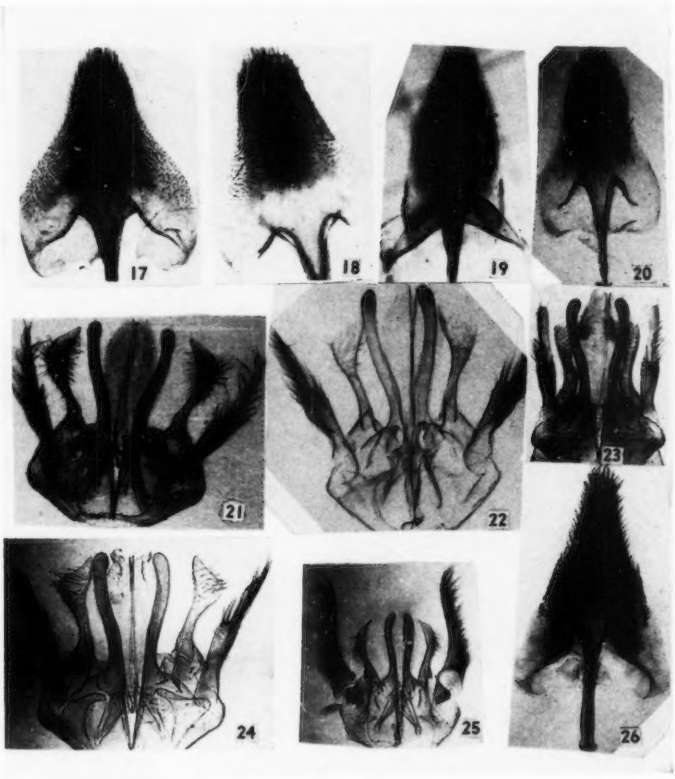
The genitalia of this species is characterized by the volsellae which has

the upper half bare of hair. The last ventrite is similar to *illinoensis*, except that the semi-transparent membrane on the edge starts nearer the tip than in the former species. Genitalia length 1.3 mm, wide 0.9 mm. I have seen this only from Arizona, its type locality. Figs. 28, 31.

ANOPLIUS PUELLA Banks

Anoplius puella Banks, Can. Ent. 73, 1941, p. 121. Male (o.d. Texas. M.C.Z.).

This species is easily distinguished by the markings on the pronotum and basal abdominal segments, as indicated in the key.



Figs. 17-26.—17. *Anoplius tarsatus* Banks, last ventrite ×62; 21. *A. tarsatus* Banks, genitalia ×42; 18. *A. subtarsatus* n. sp., last ventrite ×45; 22. *A. subtarsatus* n. sp., genitalia ×35; 19. *A. illinoensis* (Robertson), last ventrite ×35; 23. *A. illinoensis* (Robertson), genitalia ×40; 20. *A. imbellis* Banks, last ventrite ×43; 24. *A. imbellis* Banks, genitalia ×49; 25. *A. hispidulus* n. sp., genitalia ×42; 26. *A. hispidulus* n. sp., last ventrite ×32.

ANOPLIUS SELKIRKENSIS Banks

Anoplius selkirkensis Banks, Bull. Mus. Comp. Zool. 63, 1919, p. 234. Male, female (o.d. B. Col. Cornell Uni. key).

The last ventrite is not available. The genitalia as shown in the figure is much like virginiensis, and when the last ventrite becomes available this may be a synonym of that species. Fig. 52.

ANOPLIUS SIMULANS (Cresson)

Pompilus (*Pompilus*) *simulans* Cresson, Proc. Bost. Soc. Nat. Hist. 12, 1869, p. 367. Male (o.d. Mexico). *Anoplius simulans* Bradley, Notulae Naturae, Acad. Nat. Sci. Phila. 145, 1944, p. 9. Male (pars. desc. Mexico. new comb.).

The last ventrite is not available. The genitalia is very much like *tarsatus*, but the volsellae have longer and more numerous hairs and these are especially more evident on inner side where they extend up to and cover the tip as they do not in tarsatus; the parameres on the other hand are not so heavily haired but have a long bare space on upper inner half. Fig. 8.

ANOPLIUS TARSATUS Banks

Pompilus tarsatus Cresson, Proc. Amer. Ent. Soc. 1, 1863, p. 317. (cat. Moss.), *Anoplius tarsatus* Banks, Bull. Mus. Comp. Zool. 63, 1919, p. 234. Female (o.d. Cal. Key. Cornell Uni.).

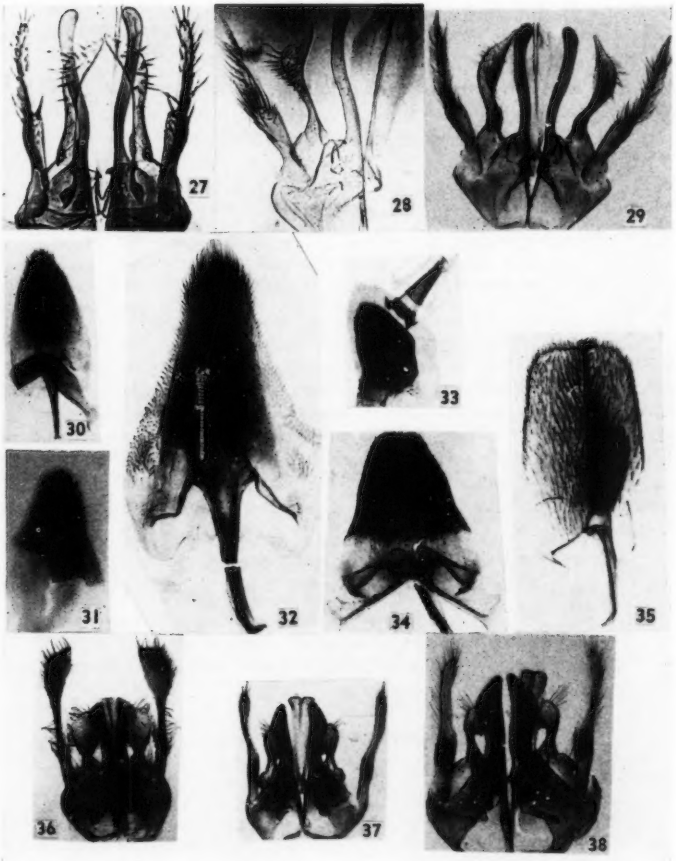
This species was described in the female, but the male here figured is probably the male, and was so considered by Banks. The color is bluish black, not so highly colored as *aenopurpureus*. The last ventrite is very characteristic by virtue of its very wide base with the semi-transparent membrane on edge covering about three-fourths of the basal part of segment; this edge is wide and hairy all over. Genitalia is also characteristic, as can be seen from the figure. Very good hair brushes on the fourth and fifth ventrals, with a few long hairs on the third. The third cubital cell is very wide open on the marginal vein. Length of head and thorax 4.3 mm, abdomen 4.6 mm, fore wing 6.3 mm, rear wing 5.0 mm, genitalia length 0.93 mm, width 0.66 mm, last ventrite length 1.26 mm, width 0.73 mm. Figs. 17, 21.

I have seen this species from Neb., Cal. and Ore.

ANOPLIUS VENTRALIS (Banks)

Psammochares ventralis Banks, Journ. N. Y. Ent. Soc. 18, 1910, p. 120. Male (o.d. Va. M.C.Z.). *Psammochares ventralis* Leonard, Cornell Uni. Agr. Exp. Stat. Mem. 101, 1928, p. 986 (N. Y.).

The genitalia is very characteristic by virtue of the long, very fine hair on volsellae which is directed forward, and by the shape and pointed tip of this part. The last ventrite has a very short tip that is free of the transparent membrane which is present over the edge of most of the ventrite; the hairs on parameres are also fine; an extra heavy hair brush on fourth ventrite, about as wide but heavier than the one on the fourth, with a slightly smaller one on the fifth; the tips of the hairs on these brushes are whitish in reflected light, with the hair in the middle of segment shorter than the



Figs. 27-38.—27. *Anoplius virginiensis* (Cresson), genitalia ×47; 30. *A. virginiensis* (Cresson), last ventrite ×43; 28. *A. papago* Banks, genitalia ×30; 31. *A. papago* Banks, last ventrite × ?; 29. *A. ventralis* Banks, genitalia ×42; 32. *A. ventralis* Banks, last ventrite ×43; 33. *Pyconopompilus sculleni* n. sp., last ventrite ×28; 37. *P. sculleni* n. sp., genitalia ×38; 34. *P. eureka* (Banks), last ventrite ×36; 38. *P. eureka* (Banks), genitalia ×35; 35. *P. catalinae* (Banks), last ventrite ×39; 36. *P. scelestus*, genitalia ×23.

ones on the edge; veins in rear wings almost interstitial, third cubital cell one half as long on the marginal vein as the second cell.

Length: Head and thorax 4.0 mm, abdomen 5.0 mm, fore wing 7.3 mm, rear wing 5.9 mm, genitalia length 0.93 mm, width 0.79 mm, last ventrite length 1.46 mm, width 0.79 mm. Figs. 29, 32.

I have seen this species from Cal., Colo., Mich., Neb., Fla., S. D., and Wash., D. C.

ANOPLIUS VIRGINIENSIS (Cresson)

Pompilus virginiensis Cresson, Trans. Amer. Ent. Soc. 1, 1867, p. 92. Male (o.d. W. Va. Amer. Ent. Soc.). *Pompilus virginiensis* Cresson, Trans. Amer. Ent. Soc. 2, 1887, p. 271. Male (Cat. Can., W. Va.). *Anoplius virginensis* Viereck, Kpt. N. J. State Mus. for 1909, 1910, p. 674 (N. J.). *Psammochares* (*Anoplius*) *virginiensis* Leonard, Cornell Uni. Agr. Exp. Stat. Mem. 101, 1928, p. 1928, p. 987. (N. Y.). *Psammochares* (*Anoplius*) *virginiensis* Viereck, Bull. Conn. Nat. Hist. Sur. 1917, p. 633. (key. Conn.). *Anoplius virginiensis* Brimley, Journ. Elish. Mitch. Sci. Soc. 52, 1936, p. 128. (key N. C.).

This species has the wings only sightly yellowish, but the tips are much darker; the lateral ocelli are as far apart as their distance from the eye margin; appressed silvery hair on clypeus, face, apical half of front, basal antennal segment, posterior orbits, thorax coxae, and basal abdominal segment; the fourth and fifth ventrals when seen from the side with long upright hair over whole surface, rather sparsely located and when seen from below, distributed rather evenly over the whole surface, basal half of sixth almost devoid of hair; longer spur of posterior tarsi five sixths as long as its metatarsal joint.

Length: Head and thorax 3.65 mm, abdomen 4.60 mm, fore wing 6.62 mm, rear wing 4.64 mm, genitalia length 0.86 mm, width 0.53 mm, last ventrite length 1.12 mm, width 0.53 mm. Figs. 27, 30.

I have seen this species from Mich., Ill., Colo., La., Md., N. H., N. J., N. Y., Pa., Ohio, Ore., Va., W. Va., Wash., Wis., and Tenn. I have this species from eighteen counties in Michigan.

ANOPLIUS WHEELERI Banks

Anoplius wheeleri Banks, Can. Ent. 71, 1939, p. 228. Male, female (o.d. Conn., Mass. M.C.Z.).

This species was presumably described from both the male and female, but for some reason I have no record of the genitalia of the male, so cannot show photos of the genitalis and last ventral of this species.

KEY TO GENUS ANOPLIUS IN THE MALES

1. Posterior edge of pronotum whitish, and when seen from above with white hairs; thorax and basal abdominal segment with silvery reflection; apical border of first tergite and entire second tergite and basal part of second ventrite, yellowish; last tergite with silvery pubescence ..... *puella* Banks
1. Posterior edge of pronotum not white and no yellow on abdomen 2
2. Whole insect purplish or bluish (Antilles) fig. 7 ..... *aenopurpureus* (Fox)
2. Insect not bluish or purplish, or if so western 3

3. No ventral hair bands in the accepted sense, but some upright hair on ventrites that normally have hair bands 4

3. Ventral hair bands present, although they may be of short hair; considered hair bands when either long, thick, and evident, or when short but visible as thick tufts either when seen from the side or below 6

4. Some sericeous hair on thorax and face and genitalia similar to ventralis, with volsellae pointed and fine hair over the surface ..... *selkirkensis* Banks

4. Last ventrite very broad with very long hair extending backward; volsellae very different from the preceding, either very broad and thick, or very narrow, long and bent at basal third 5

5. Sericeous hair on face just under antennae but none on thorax, or only a faint trace; parameres very broad and heavy, last ventrite ovoid, pointed, and with very long hair. Figs. 13, 14 ..... *banksi* n. sp.

5. Sericeous hair on face, legs and thorax; volsellae very characteristic, long slender, and bent at basal third; last ventrite very broad at tip, somewhat wedge-shaped, and with very long hair. Figs. 15, 16 ..... *ithica* Banks

6. When the insect is seen from below at a slight angle the hair bands are longitudinal on edges of ventrites four and five, and with no hair in between 7

6. When seen as above the hair bands are not seen as longitudinal lines, but with long hair between the hair on edges of ventrites 9

7. When seen from the side the hair bands are just visible as thick mats, but when seen from below at an angle they appear as two parallel longitudinal ridges on edge of ventrites four and five; last ventrite long and pointed at apex, parameres longer than the rest of genitalia. Figs. 25, 26 ..... *hispidulus* n. sp.

7. When seen from the side the hair bands have very long hair, but when seen from below at an angle, they appear as two parallel bands similar to the preceding, but do not appear as ridges but as bands of long hair 8

8. When seen from the side, the hair bands on the fourth and fifth ventrites do not touch and hairs are relatively sparse and short; when seen from below at an angle they show up as two interrupted lines, with no hair between and space between shiny; base of parameres very broad to middle and then tapering to a point; last ventrite suddenly expanded just beyond apical half. Figs. 9, 10 ..... *basalis* n. sp.

8. When seen from the side, the hair bands are continuous, and in view from below appear as two continuous rows; parameres of even width and not tapered to a point; last ventrite rather narrow and only slightly expanding in width just above base. Figs. 11, 12 ..... *elongatus* n. sp.

9. Hair bands appear as transverse, when seen from the side, i.e. there is a definite space between the bands on fourth and fifth ventrites, and the long hair is in a short longitudinal row, although there are partly depressed ones for a short distance before and connected with the longer ones; the space between the longer outer hairs is covered with long semi-depressed, backward directed hair; no hair bands on third and sixth ventrites 10

9. Hair bands of fourth and fifth ventrites touching, no space between them when they are in normal position, or if some space between them, small hair bands on ventrites three and six 13

10. Hair bands short but with long hairs; genitalia similar to the next, but volsellae not so pointed at the tip and the last ventrite is similar but smaller, and with the hairy-edged tip shorter; last ventral segment two thirds or less as wide as long 11

10. Hair bands may be longer and ocellar triangle is visible above surface of eye, when seen from side 12

11. Similar in genitalia and last ventrite to next, but a small species; length of head and thorax 3.4 mm, abdomen 3.3 mm, fore wing 5.3 mm, rear wing 4.4 mm;

genitalia and last ventrite same as the next in size; nearer lateral ocellus not visible above eyes, when seen from the side; far western. Figs. 20, 24 ..... *imbellis* Banks

11. Larger in size than the preceding, and eastern; head and thorax 4.0 mm, abdomen 5.0 mm, fore wing 6.6 mm, rear wing 5.3 mm ..... *imbellis v. major* n. var.

12. Ocellar triangle just barely visible above eyes when seen from the side; a very thin hair tuft on ventrite three, six to eight hairs; last ventrite broader, not so elongate, and without a semi-transparent edge extending close to tip as in the next; parameres with thicker hair than in the next, as is also true of the volsellae. Figs. 17, 21 ..... *tarsatus* Banks

12. Ocellar triangle as well as part of vertex visible above eyes, when seen from the side; a sparse tuft of hairs on ventrite three. Figs. 29, 32 ..... *ventralis* Banks

13. Hair bands on ventrites hardly more than long upright hair on ventrites four and five, with a few on third segment, which do not show up as mats when seen from below at an angle; sericeous hair on face, coxae and propodeum; wings almost hyaline but much darker at tip; basal and transverse veins interstitial; last ventrite slightly elongate with a thin semi-transparent edge on basal half. Figs. 27, 30 ..... *virginiensis* (Cresson)

13. Hair bands strong, very evident; basal and transverse veins generally not interstitial 14

14. Very strong hair on sternites three through five, none on sixth, a small open space between bands on sternites three and four, the band on three as strong as the rest 15

14. Only a trace of hair band or none on third sternite, but there may be one on sixth 16

15. Strong hair bands on sternites three to six, an open space between the ones on three and four; subdiscoidal and cubital vein in rear wings interstitial; only a very short length of front at the antennal fossae above the eye margin, when seen from the side; volsellae with fine hairs pointed toward the tip; a southeastern species. Figs. 18, 22 ..... *subtarsatus* n. sp.

15. Volsellae with thicker hairs, rather stiff (not cobwebby as preceding) and covering all sides, not just the ventral side, also this part more rounded, not so broad; parameres less hairy and with the hair projecting at an angle, so that the surface is more easily seen; Mexico. Fig. 8 ..... *simulans* (Cresson)

16. Hair bands on sternites four and five with very dense, long hair, and the hair bands continuous when the segments are in their usual position, but the hair bands not very long on the sternites; wings brown all over but more so at tip; face with silvery pubescence; parameres long pointed at inner upper end. Figs. 19, 23 ..... *illinoensis* (Robertson)

16. Hair bands on sternites four to six inclusive; veins interstitial in the rear wings; volsellae with the upper half bare of hair; parameres very short; western. Figs. 28, 31 ..... *papago* Banks

The Genus PYCNOPOMPILUS Ashmead

Pycnopompilus Ashmead, Can. Ent. 34, 1902, p. 83 (key. Genotype *Pompilus scelestus* Cresson).

Most of the species in this genus were described in the genus *Psammochares*. In Ashmead's key he states that the claws of the male are cleft, which is only part true, since the last two pairs of legs have the claws with a small tooth on the middle of the ray. The female of this genus has good tarsal comb, with the spine on the middle of the second joint of the fore tarsi as long as the one at end and at least three times the width of the

joint; spines under the last joint of fore and posterior tarsi; antennae long with the third joint as least three times as long as wide. Both sexes have the following combination of characters in common: pronotum strongly angulate; marginal cell large and longer than its distance to wing tip; third cubital cell about as long on marginal vein as the second, and not much shorter on the marginal than on the cubital cell, thus making the third cubital cell almost rectangular; basal vein slightly basal of the transverse vein, although it may be almost interstitial; subdiscoidal vein in rear wings generally beyond the cubitus, although it also may be interstitial with the cubitus; propodeum with upright hair, and generally with the head long haired. The male has only the first pair of claws cleft, the other two pairs with a tooth; fore coxae and head longhaired, in general; third joint of antenna generally longer than the first, and about two to three times as long as wide; last ventrite except in a very few cases with a ridge, roof-shaped, or with a protuberance near base; volsellae very characteristic and no other genus has a volsellae that can be mistaken for the one of this genus; the volsellae has a small hook at the upper inner end, and is very broad at the upper half; parameres may be narrow in their whole length or narrow at base and expanding at upper half or third into a very broad portion, which is two or more times broader than the basal part; parapenial lobes very broad and generally as long as the aedeagus. The color is black or bluish, with one species with the basal part of abdomen red. The genitalia as well as the last ventrite are very characteristic for the genus.

Pycnopompilus subscelestus n. sp.

Holotype male.—Completely black, except for a short narrow white line on upper part of posterior orbits; long hair on head, clypeus, mentum, mandibles, posterior orbits, fore coxae, neck, pronotum, mesonotum, propodeum, and a very few short ones on last two coxae and first abdominal tergite; when seen from the side the clypeus is slightly bulged in center, and the lateral ocellus and a very short distance of antennal fossae visible above the surface of eyes; posterior orbits widest about the middle and one-half a wide as eye; anterior ocellus slightly more than its diameter from the laterals and these as far apart as their distance to eye margin; a narrow line on front; when seen from in front, the ocellar triangle is just visible above the vertex; pronotum strongly angulate, propodeum long haired and sloping from base to apex, more so at apex than base; wings deep fuliginous, no more so at apex than the rest of wing; third cubital cell wide open at top and slightly longer on marginal vein than the second cell, the second only nine-sixteenths as long on cubitus as the third cell; the first recurrent vein meets the second cubital cell at apical fourth and the second recurrent at the middle of the third cubital cell; basal vein, in fore wings, slightly basad of the transverse vein, and the subdiscoidal vein in rear wings is slightly beyond the cubitus; marginal cell almost one and one half times as long as its distance to wing tip; no spines on fore femur and a few spine pits on last two pair just before tip on dorsal surface; fore tibiae with two small spines on ventral surface and three on outside, the last two pair spined with fairly long spines; longer spur of posterior tibiae not quite

two-thirds as long as its metatarsal joint; the first joint of antennae four-fifths as long as the third, while the fourth and ultimate joints are subaequal in length to the third.

Length: Head and thorax 5.0 mm, abdomen 5.3 mm, fore wing 7.6 mm, rear wing 6.0 mm, genitalia length 1.32 mm, width 0.80 mm, last ventrite length 1.53 mm, width 0.47 mm. Figs. 39, 40.

Holotype male: Ute Creek, Colo., VII-30, R. W. Dawson (Neb.).

Paratypes: Gratiot Co., Mich., VI-2-47, R. R. Dreisbach (MCZ); Huron Co., Mich., IX-12-27, F. M. Gaige (MZ).

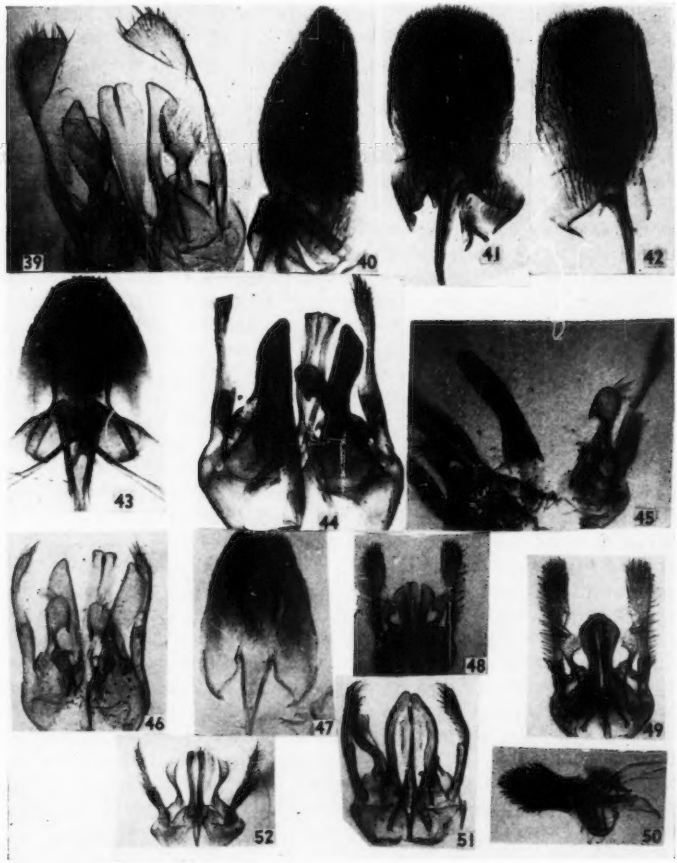
The paratypes have the following measurements: head and thorax 4.3 mm, abdomen 4.7 mm, fore wing 6.65 mm, rear wing 5.4 mm.

Pycnopompilus siouxensis n. sp.

Holotype male.—Completely black; a very small species for the genus; very hairy all over the head and neck with unusually long hair; a very few long upright hairs on pronotum and propodeum; when seen from the side the clypeus is flat, truncate and without a smooth edge; eye reaches from base of clypeus to top of vertex, but the whole front slightly raised above the surface of eyes, when seen from the side, and the posterior orbits are very narrow, hardly one-fourth the width of eye; anterior ocellus two times its diameter from the laterals and these about as far apart as their distance to eye margin a slight depression in front of fore ocellus but no line on front; when seen from in front the ocellar triangle is not raised above vertex; antennae lost; pronotum angulate, propodeum very short and with a moderate sulcus over the whole length; third cubital cell on marginal vein and as long on this vein as the second cubital cell, while it is one and one half times as long on the cubitus as the second cell; both recurrent veins received by their respective cubital cells at about the middle; basal vein in fore wings only slightly basad of the transverse vein and in rear wings the veins are interstitial; wings brownish all over but more so at tip; there is no second intercubital vein in one wing, the two cells united; legs as in the other species, except the claws; fore claws split but the last two pairs with only a very small tooth which is unique in this genus; genitalia with volsellae with about the same shape of that of *P. scelestus*, but the parameres are no longer than the aedeagus, and in this is distinct from any other species of the genus; last ventrite is also different in the location of the ridge or hump, as can be seen from the figure; there are two very evident ridges which arise slightly before the middle of segment and extend to a short distance from the tip, and from the end of these two ridges the hump slopes to the surface of the tip, the hump is enclosed between these two ridges; in the other similar species these ridges and hump are located nearer the base; the tip of the ventrite is slightly emarginate.

Length: Head and thorax 3.3 mm, abdomen 3.3 mm, fore wing 5.0 mm, rear wing 4.0 mm, genitalia length 0.80 mm, width 0.53 mm, last ventrite length 0.86 mm, width 0.45 mm. Figs. 46, 47.

Holotype male: Glen, Sioux Co., Neb., 4000', VIII-13-06, H. S. Smith (Neb.).



Figs. 39-51.—39. *Pyconopompilus subcelestus* n. sp., genitalia ×38; 40. *P. subscelestus* n. sp., last ventrite ×35; 41. *P. scelestus* (Cresson), last ventrite ×38; 49. *P. catalinae* (Banks), genitalia ×25; 42. *P. catalinae* Banks, last ventrite ×39; 48. *P. lasiope* Banks genitalia ×21; 43. *P. luctuosus* (Cresson), last ventrite × 53; 44. *P. luctuosus* (Cresson), genitalia ×45; 45. *P. arctus* (Cresson), genitalia ×35; 46. *P. siouxensis* n. sp., ×42; 47. *P. siouxensis* n. sp., last ventrite ×37; 50. *Agenioideus humilis* (Cresson), last ventrite ×49; 51. *A. humilis* (Cresson), genitalia ×45; 52. *Anoplius puella* Banks, genitalia.

Pycnopompilus sculleni n. sp.

Holotype male.—Completely black except for a small white line on anterior orbits just above antennal fossae and a small white line on posterior orbits close to top, these two lines very short and narrow; the clypeus, face and inner orbits to just above the antennae with silvery pubescence; the head very heavily haired with long hair, and also just about the same amount of hair on the neck, fore coxae, sides of pronotum and the propodeum, with a few shorter ones on mesonotum with practically no upright hair on abdomen; when seen from the side, the clypeus is flat until the apical third where it turns downward so that the tip is considerably below the level of the base, the nearer of the lateral ocelli just visible above the surface of the eyes, and all the front is just barely visible; posterior orbits very narrow, a little more than one-fourth as wide as eyes; when seen from in front, the ocellar triangle is slightly raised above the surrounding surface; eyes as far apart at apex as at the clypeus, but there is a slight emargination just above the antennal fossae; anterior ocellus its diameter from the laterals and these three-fifths as far apart as their distance to eye margin; a slight sulcus from anterior ocellus to antennal fossae; first joint of antennae with appressed brownish hair in front; third, fourth and apical joints of equal length and slightly longer than the first joint which is twice as long as the second; the whole antennae covered with short, stiff, whitish hair; pronotum strongly angulate, propodeum in a smooth curve from base to tip; wings brownish all over; second and third cubital cells of equal length on the marginal vein, but the third is one-third longer on the cubitus than the second; the first recurrent meets the second cubital cell beyond the middle, but before the apical third and the second recurrent vein meets the third cubital just before the middle; marginal as far from the wing tip as it is long; basal vein basad of the transverse and the subdiscoidal vein in rear wings is far beyond the cubitus; no hairs or spines on femur; fore tibiae with a few spines on ventral surface and at tip, last two pairs with several rows on dorsal surface as well as a few ventral spines; posterior tibiae with a well marked band of brownish hair on the inner edge running the length of joint; no spines under the last joint of fore and middle tarsi and only a very few small ones under this joint on last pair; third, fourth and fifth joints of fore tarsi have their lengths in ratio of 15-5-30, while the last pair have them in ratio of 30-20-30; longer spur of posterior tibial joint seven-tenths as long as its metatarsal joint.

Length: Head and thorax 3.90 mm, abdomen 3.95 mm, fore wing 6.30 mm, rear wing 4.5 mm, genitalia length 1.10 mm, width 0.73 mm, last ventrite length 1.05 mm, width 0.40 mm. Figs. 33, 37.

Holotype male: Cornucopia, Ore., 7100′, VII-25-36, H. A. Scullen (MCZ).

PYCNOPOMPILUS ANOPLINUS (Banks)

Psammochares anoplinus Banks, Bull. Mus. Comp. Zool. 63, 1919, p. 232. Female (o.d. Cal., Ore., Can. key. MCZ).

This species was described in the female only and no male is known at present.

PYCNOPOMPILUS ARCTUS (Cresson)

Pompilus arctus Cresson, Proc. Ent. Spoc. Phila. 4, 1865, p. 453. Male (o.d. Colo. Amer. Ent. Soc.). *Pompilus arctus* Cresson, Trans. Amer. Ent. Soc. 1, 1867, p. 92. Male (desc. Colo. Terr. Amer. Ent. Soc.). *Pompilsu arctus* Cresson, Trans. Amer. Ent. Soc. 2, 1887, p. 270. Male (Cat. Col.).

This species is known in the male only. I do not have a photo of the last ventrite at the present time. The genitalia is very similar to that of the new species *sculleni*, but differs in the volsellae, which are long in the top broad part of *sculleni* and much shorter in this species. It differs from the species *eureka* which it closely resembles in the lack of long hair on the parameres, while *eureka* has long hair on all sides of the parameres. For a comparison of this species with scelestus see that species. Fig. 45.

PYCNOPOMPILUS ASTUR (Banks)

Psammochares astur Banks, Journ. N. Y. Ent. Soc. 19, 1911, p. 225. Female (o.d. Arix. Biederman). *Psammochares astur* Leonard, Cornell Uni. Agr. Exp. Stat. Mem. 101, 1928, p. 986. (N. Y.). *Psammochares astur* Brimley, Journ. Elish. Mitch. Sci. Soc. 52, 1936, p. 129. (o.d. pars. desc. N. C. Key.). *Psammochares astur* Brimley, Insects of N. C. 1938, p. 434. (N. C.).

This species is known in the female only. The face and clypeus has white sericeous hairs, wings are black, there is a line on the front between the fore ocellus and the antennal fossae, and there is a sulcus on propodeum.

PYCNOPOMPILUS CATALINAE (Banks)

Psammochares catalinae Banks, Psyche 40, 1933, p. 7. Female (o.d. Ariz. MCZ).

The species *catalinae* was never described in the male and the following is a brief description. Head, neck, fore coxae, pronotum, and propodeum bearing very long, upright hair; a very small white spot on upper posterior orbits, the rest of body entirely black; posterior ocelli as far apart as their distance to eye margin, no line or sulcus on front; posterior orbits very narrow; first joint of antennae seven-tenths as long as the third joint which is subaequal to the fourth; pronotum angulate; wings dark brown all over; basal vein in fore wings is basad of the transverse median, and the subdiscoidal in rear wings is interstitial with the cubitus; first recurrent vein meets the second cubital cell at apical third and the second recurrent meets the third cubital cell before the middle; last ventrite is very characteristic and distinguishes this from all other species; a very high protuberance on the base which covers less than the basal half of segment but more than the basal third, and which ends abruptly and has a sharp declivity on the posterior edge, which however extends backward a short distance as a low ridge, and this posterior declivity is slightly concave and has numerous rather long hairs on the ridge; the parameres of genitalia have a broad apical third which however is only about two to three times as wide as the basal two-thirds, but not as wide as scelestus or subscelestus n. sp.; volsellae with inner side of base in a smooth long curve and the inner part of broad tip slightly convex and not very deep, in contrast to scelestus which has a shorter less curved base and a straight inner side of broad tip which is very deep, about one and one-half to one and one-third times as long

as the former; the volsellae at the outer tip have longer, heavier, thicker hair than the two mentioned; genitalia almost exactly like *lasiope*, but the hair on parameres, volsellae, and at the base of volsellae are thicker in diameter and longer, and the parapenial lobes are wider; longer spur of posterior tibiae three-fourths as long as its metatarsal joint; inner ray of fore tarsi short and blunt, the other two pairs with a small tooth.

I have seen this species from Calif. and Utah.

Length: Head and thorax 4.96 mm, abdomen 4.7 mm, fore wing 7.90 mm, rear wing 5.95 mm, genitalia length 1.19 mm, width 0.66 mm, last ventrite length 1.3 mm, width 0.59 mm. Figs. 42, 49.

PYCNOPOMPILUS EUREKA (Banks)

Psammochares eureka Banks, Bull. Mus. Comp. Zool. 63, 1919, p. 232. Male, female (o.d. Cal., key. MCZ).

The last ventrite of this specie is only very lightly roof-shaped on the apical half, but there is a very definite hump on the basal third sloping to an almost flat surface beyond the middle; the whole head and thorax is covered with brownish, almost reddish hair; a definite line from anterior ocellus to the antennal fossae; pronotum strongly angulate; wings infumate all over but more strongly so at the tip; basal vein basad of the transverse vein, and the cubitus and subdiscoidal veins in rear wings are interstitial; the first recurrent vein meets the second cubital cell at last third to fourth of cell; the parameres in the male genitalia are narrow and are distinguished by the presence of long hairs on the outer surface, while *arctus* and *luctuosus* do not have any hairs visible on the outer surface; the last ventrite has what appears to be a slight transverse groove at the base, just before the beginning of the hump. Genitalia length 1.19 mm, width 0.86 mm, last ventrite length 0.66 mm, width 0.79 mm. Figs. 38, 45.

PYCNOPOMPILUS LASIOPE (Banks)

Psammochares lasiope Banks, Can. Ent. 51, 1919, p. 81. Female (o.d. N. Y. MCZ). *Psammochares lasiope* Leonard, Cornell Uni. Agr. Exp. Stat. Mem. 101, 1928, p. 986. (N. Y.).

This species was described in the female sex and the male was never described and a short description follows. There should be no doubt as to the association of the sexes in this case, as they both have the base of the abdomen red and are the only species that do have this color. Black except for the basal segments of the abdomen which are red, and for two small white lines on head, one just above the antennal fossae on inner orbits and the other on the upper part of posterior orbits next to the eye; head with considerable hair but the hair not very long, the fore coxae and pronotum also with upright hair, and the propodeum with somewhat shorter hair; clypeus has a slightly turned up front edge; fore ocellus one and one half times its diameter from the laterals and these very slightly farther apart than their distance to eye margin; a line on front; third joint of antennae one-third longer than the first; pronotum strongly angulate; second and third cubital cells of about equal length on the marginal vein and the third is one-third longer on the cubitus than the second, the third cubital one half as long on the marginal vein as on the

cubitus; the first recurrent vein meets the second cubital cell before the apical third and the second recurrent vein meets the third cubital cell just before the middle; basal vein basad of the transverse vein and in rear wings the veins are interstitial; the longer spur of posterior tibiae two-thirds as long as its metatarsal joint.

Length: Head and thorax 3.9 mm, fore wing 5.9 mm, rear wing 4.3 mm, genitalia length 1.25 mm, width 0.73 mm, last ventrite length 1.25 mm, width 0.53 mm. Figs. 42, 48.

PYCNOPOMPILUS LUCTUOSUS Cresson)

Pompilus luctuosus Cresson, Proc. Ent. Soc. Phila. 4, 1865, p. 452. Female (o.d. Colo. Amer. Ent. Soc.). *Pompilus luctuosus* Cresson, Trans. Amer. Ent. Soc. 1, 1867, p. 88. Male, female (desc. Hudson Bay, Me., Ill., Colo. Dak. terrs. Amer. Ent. Soc.). *Pompilus luctuosus* Cresson, Trans. Amer. Ent. Soc. 2, 1887, p. 271. Male, female (Brit. Am. U. S.). *Anoplius luctuosus* Viereck, Rpt. N. J. State Mus. for 1909, 1910, p. 674. (N. J.). *Psammochares luctuosus* Viereck, Bull. Conn. Nat. Hist. Sur. 1917, p. 633. (key. Conn.). *Psammochares luctuosus* Rohwer, Proc. U. S. Nat. Mus. 53, 1917, p .239. Male, female (Cal.). *Anoplius luctuosus* Banks, Bull. Mus. Comp. Zool. 63, 1919, p. 234. (B. Col., Ore., Cal., Wash. key male, female). *Psammochares luctuosus* Leonard, Cornell Uni. Agr. Exp. Stat. Mem. 101, 1928, p. 987. (N. Y.).

Cresson originally described the female of this species from Colorado and then two years later described the male from the localities as noted in the second reference above. These localities were widely separated, and it is very doubtful if these sexes are correctly associated. The genitalia is very similar to those of *sculleni* and *arctus*, but differs from *sculleni* in the much larger last ventrite and the much heavier ridges on the basal half, by the shorter length of the broad part of the volsellae, and by the fact that the volsellae are longer compared to the parapenial lobes, but is similar in the lack of long hair on the parameres; it differs from *arctus* by the length of the volsellae compared to the parapenial lobes, but otherwise is very similar to *arctus*. It is possible that when the last ventrite becomes available that this species and *arctus* are the same species. This differs from *eureka* by the absence of long hairs on the parameres and by the great dissimilarity of the last ventrites, as can be seen by an inspection of the plates.

Length: Head and thorax 4.3 mm, abdomen 4.3 mm, fore wing 6.60 mm, rear wing 5.20 mm, genitalia length 0.93 mm, width 0.66 mm, last ventrite length 1.12 mm, width 0.46 mm. Figs. 43, 44.

PYCNOPOMPILUS SCELESTUS (Cresson)

Pompilus scelestus Cresson, Proc. Ent. Soc. Phila. 4, 1865, p. 451. Male, female (o.d. Colo.). *Pompilus scelestus* Cresson, Trans. Amer. Ent. Soc. 1, 1867, p. 88. Male, female (pars. desc. Conn., Col., Ter., N. J., Amer. Ent. Soc.). *Pompilus scelestus* Cresson, Trans. Amer. Ent. Soc. 4, 1872, p. 203. Female (Texas). *Pompilus scelestus* Cresson, Trans. Amer. Ent. Soc. 2, 1887, p. 271. Male, female (Cat. Ca. U. S.). *Psammochares scelestus* Viereck, Bull. Con. Nat. Hist. Sur. 1917, p. 633. (key. Conn.. *Psammochares scelestus* Rau, Wasp Studies Afield 1918, pp. 64-67. (habits). *Psammochares scelestus* Banks, Bull. Mus. Comp. Zool. 63, 1919, p. 233. Male, female (Wash., Cal. key). *Psammochares scelestus* Leonard, Cornell Uni. Agr. Exp. Stat. Mem. 101, 1928, p. 986 (N. Y.). *Psammochares scelestus* Brimley, Journ. Elish. Mitch. Sci. Soc. 52, 1936, p. 129. Male (N. C. key). *Psammochares scelestus* Brimley, Insects of N. C. 1938, p. 434. (N. C.).

This species was described in both sexes, but whether they are the same species is questionable. The head of the male is very hairy, and there are no sericeous hairs on the head. The last ventrite has a ridge over the whole length extending over the whole segment with the widest part about the middle and tapering off from there to the apex. This can been seen by an inspection of the plate. The parameres are very characteristic and can only be confused with those of *subscelestus* n. sp., but are dissimilar enough to be distinguished on this character, while the last ventrites are also very dissimilar and confirm the differences in the parameres.

Length: Head and thorax 4.0 mm, abdomen 4.3 mm, fore wing 6.65 mm, rear wing 5.2 mm, genitalia length 1.32 mm, width 0.73 mm, last ventrite 1.32 mm, width 0.66 mm. Figs. 35, 36.

PYCNOPOMPILUS SUBLAEVIS (Banks)

Psammochares sublaevis Banks, Ann. Ent. Soc. Amer. 14, 1921, p. 20. Female (o.d. Ind., N. Y. MCZ). *Psammochares sublaevis* Leonard, Cornell Uni. Agr. Exp. Stat. Mem. 101, 1928, p. 986. (N. Y.).

This species was described in the female sex and no male has been associated with it.

KEY TO THE GENUS PYCNOPOMPILUS ASHMEAD (Males)

1. Basal segment of abdomen red; last ventrite with a central longitudinal ridge on basal half, which tapers out to tip from about the middle; last ventrite one and one half times as long as wide ..... *lasiope* Banks
1. Basal segment of abdomen not red, black; last ventrite may have a central longitudinal ridge 2
2. No central longitudinal ridge, although there may be a pair of longitudinal ridges dividing plate into thirds, these show up from the side as a hump but when seen from beneath the ridges show up as can be seen from the figures 3
2. A central longitudinal ridge on last ventrite which does not extend to the tip in its full width 7
3. No ridge whatever on last ventrite, but center may be slightly raised; parameres narrow 4
3. A pair of longitudinal ridges, dividing ventrite into thirds 5
4. Parameres bearing long hairs over the whole surface ..... *eureka* (Banks)
4. Parameres without any long hairs on their surface ..... *arctus* (Cresson)
5. The two ridges are on the base and hardly reach beyond the middle; parameres narrow 6
5. The two longitudinal ridges are on the apical part of ventrite, beginning about the middle, and no not quite reach the tip; parameres narrow and bearing a few long hairs ..... *siouxensis* n. sp.
6. The two ridges show up as evident ridges and are located on base and do not quite reach the middle of segment; volsellae with the broad apical part not of unusual length, parameres without long hair ..... *luctuosus* (Cresson)
6. The two ridges are hardly ridges, but show up more as a broad hump which covers most of the basal part of sternite and which has two small protuberances at the outer posterior corners of the large hump; volsellae exceptionally long on the apical part, the longest of the genus ..... *sculleni* n. sp.
7. The ridge of last ventrite extending over the whole length of ventrite in a smooth curve from base to tip with the greatest width in the center and with the para-

meres very narrow just above tip of volsellae with the apical third triangular-shaped, much the broadest at the tip, the inner side in a straight line ..... *subscelestus* n. sp.

7. If ridge over the whole sternite parameres not triangular-shaped, and hardly any broader at the tip than in the middle of the broad part 8

8. Ridge on last ventrite about 5(1) and parameres very broad at upper third but not broader at tip than near the middle of the broad section and not triangular-shaped ..... *scelestus* (Cresson)

8. Parameres narrow, not very broad in upper third or broadest in upper third, but only two to three times as broad as the basal part and where they are broad the last ventrite has a hump on base that ends abruptly about the middle and narrows out in a very short distance, and this ridge concave and with rather long hair on the ridge 8

9. Parameres broad and with the protuberance ending abruptly and slightly concave on posterior slope ..... *catalinae* (Banks)

9. Parameres very narrow over their whole length, and the volsellae longer on the upper inner edge of broad section ..... *arctus* (Cresson)

THE GENUS AGENIOIDEUS ASHMEAD

Agenioideus Ashmead, Can. Ent. 34, 1902, p. 85. o.d. Genotype—*Ponpilus humilis* Cresson). *Agenioideus* Banks, Bull. Mus. Comp. Zool. 61, 1917, p. 107 (key). *Agenioideus* Banks, Bull. Mus. Comp. Zool. 63, 1919, p. 231 (key). *Agenioideus* Dreisbach, Ent. Americana, in Press. (key).

Pompilus humilis Cresson, Trans. Amer. Ent. Soc. 1, 1867, p. 91. Female (o.d. N. Y., Amer. Ent. Soc.). *Anoplius humilis* Viereck, Ent. News 17, 1906, p. 304. Male, female (desc. male. Conn. Waldon). *Sericopompilus* Banks, Jr. N. Y. Ent. Soc. 19, 1911, p. 229. (key). *Agenioideus humilis* Banks, Bull. Mus. Comp Zool. 63, 1919, p. 239 (Brit. Col.). *Sericopompilus humilis* Leonard, Cornell Uni. Agr. Exp. Stat. Mem. 101, 1928, p. 987 (N. Y.). *Agenioideus humilis* Hurd, Pan Pac. Ent. 23, 1947, pp. 132-134. Male, female (desc. N. Y., Can., Brit. Col., Cal.). *Agenioideus humilis* Dreisbach, Ent. Americana, in press. (photomicrograph of male gen.).

This genus is represented by a single species and a very complete description was given by Hurd in the reference above. Figs. 50 and 51 show the genitalia and last ventrite of the male.

In addition to the localities given by Hurd, I have seen this species from Wisc. and Neb., length of the genitalia 0.66 mm, width 0.40 mm, last ventrite length 0.52 mm, width 0.17 mm.

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An Intergrade Population of the Texas Subspecies of Desmognathus fuscus

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Introduction

The range and status of *Desmognathus fuscus brimleyorum* and *D. f. auriculatus* in East Texas has been an open question. Sanders and Smith (1949) reported a 1938 collection from Hardin County which greatly extends the southern range of *brimleyorum* and records for the first time *auriculatus* from that state. Burger, Smith, and Smith (1949) recorded *auriculatus* from Orange County, two additional specimens from Hardin County, and a specimen of *brimleyorum* from Jasper County. Since Bishop's summary (1943) of our knowledge of these races, little has been added to the life history or ecology of the forms.

Material presented in the following report is based primarily on observations made intermittently at a site fifteen miles south of Livingston, Polk County, Texas, from August to December, 1948. In addition to the field notes, a series of 35 specimens of juveniles and adults were collected for morphological study. Previously the present author collected two specimens four miles west of Shepard, San Jacinto County, on September 11, 1947. These were assigned to the subspecies *auriculatus* although somewhat smaller and with less heavily pigmented venters than typical forms.*

Habitat

In both San Jacinto and Polk counties the habitats were similar. The San Jacinto county individuals were taken from under a moss tussock alongside a sandy bottomed, clear, cool creek. The soil in this area was sandy with four to six inches of humus and debris overlying it. Trees at this locality were predominantly oak, pine, beech and magnolia.

Specimens taken at the Polk county locality were found in or under rotting logs, under leaves, rocks and debris within the stream proper or on the water saturated banks. The stream here was a small spring-fed, clear, cool creek contained within a narrow eroded gully with sides as high as twenty feet in some places. The stream was one to five inches deep, one to three and a half feet wide, and had a sandy-red clay bottom. Its course from headwaters to point of junction with the Trinity River was slightly over a quarter of a mile. Soil of the land bounding the stream was of fine sand and sandy-loam of the Segno group.

* Sincere thanks are due Dr. S. C. Bishop for examining three specimens from the Polk County locality and to Mrs. K. Kapp for the loan of typical specimens of *brimleyorum* and *auriculatus* from the Cornell Univ. Museum for comparison.

The stream contained scant aquatic vegetation and this only near its source. Some grasses were present on the sides and bottom of the gully as were also a few bushes and an occasional tree. Predominant vegetation of the area consisted of pine, oak, holly, magnolia, beech, sycamore, and yaupon.

General Activities

During the summer months the salamanders were more frequently found under larger objects, logs and stones on the stream bank seemingly being preferred to the general debris. By late November and in December the specimens were more dispersed. At this time of the year they were readily found under loose leaves on the less steep sides of the gully. Also the adults were found more frequently in the flowing stream beneath the autumnal litter clogging the creek.

In August no larvae were noted, the population being adults and juveniles, apparently of the preceding year. Figures on random collecting until December are interesting in that they show the population to consist of about one-third more juveniles than adults.

The larvae enter the water shortly after hatching and were present in pools well into December. The latest date on which a gilled animal was seen in the water was December 18. Thus, the metamorphosis is complete by the end of December in Texas.

Food

Of the thirty-three stomachs examined, eighteen contained ingested material. Contents of four of these had been rendered unrecognizable, but that of the remaining fourteen was sufficiently intact for identification of the contained specimens to order. Twenty-one of the twenty-seven food items were arthropods, two were molluscans, and four were plant parts. None of the plant material was identifiable. The molluscan consisted of two small pulmonates which were found in a single stomach.

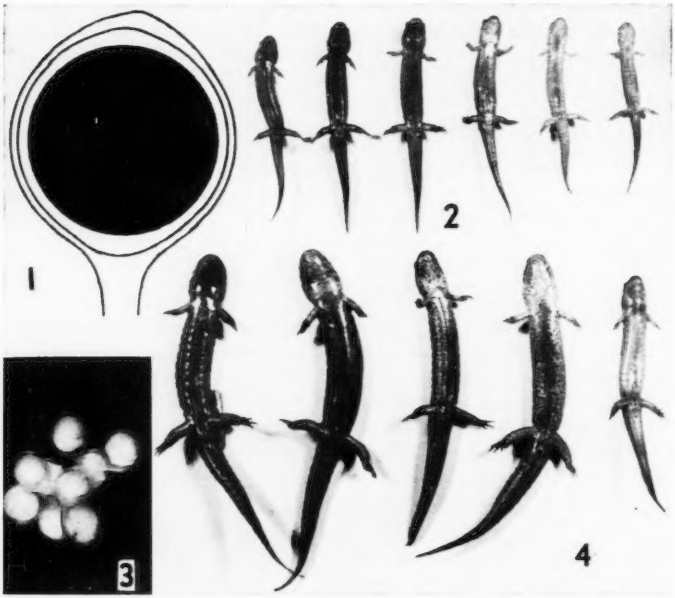
Four classes of arthropods were found, namely: Arachnoidea, Crustacea, Diplopoda, and Insecta. The first of these was represented by Araneida in two stomachs. One stomach contained a single spider; the other the remnants of an adult and an egg case enclosing twelve minute young. Of the Crustacea, only the order Anostraca was recorded; a single fairy shrimp being found in two stomachs. Only one stomach contained any Diplopoda; this was a very small millipede.

Fifteen of the twenty-one arthropods were members of the class Insecta. These were: Coleoptera, present in four stomachs, two adult beetles and two larvae; Diptera, present in three stomachs, one adult mosquito, one mosquito larva, and one unrecognizable dipteran; Hemiptera, all in nymphal stages, single examples in three stomachs; and Hymenoptera, ants were present in three stomachs, two specimens being found in one of the stomachs. In addition there was one unidentifiable insect.

EGGS

Unfortunately the necessarily irregular visits to the study area prevented the obtaining of data on courtship activities, egg deposition process, and other desirable information. However, on August 8, 1948 one mass of seven eggs was found lying on the sand next to a rotting log at the edge of the stream. On August 17 two masses were collected from cavities in rotting beech logs. One other mass was seen attached under a large root, but was not collected. After this date no new egg masses were located. Of the masses collected, one contained 16 eggs, the other 22. In the case of the smaller mass, the female was in the cavity with the eggs which were three or four days old. No parent was with the other mass; hence it appears that the guarding of the eggs is either an individual trait or else the parent leaves the eggs for intervals and returns to them later.

The egg mass (Fig. 3) is a grape-like cluster, held together by extensions of the outer envelope of each egg, these extensions forming a common stalk of gelatinous material which may be attached to the wall of the cavity or other object. In one instance this stalk was so firmly attached that bits of the wood fibers of the log came away with the mass.



Figs. 1-4.—1. Diagram of egg. 8×; 2. Series of juveniles, showing range of ventral pigmentation. 0.68×; 3. Small egg mass showing stalked condition. 1.43×; 4. Series of adults, showing range of ventral pigmentation. 0.68×.

Vitelli of the eggs are unpigmented and creamy in color. Surrounding the vitellus are two gelatinous envelopes, the inner thicker than the outer, and the outer extended into the stalk (Fig. 1). In outline the eggs are ovoid, this condition being evident in both envelopes, becoming accentuated as development progresses. Measurements made at the neural crest stage were as follows: vitellus 3-3.90 mm., average 3.44 mm.; inner envelope 3.34-4.30 mm., average 3.90 mm.; outer envelope 3.92-4.61 mm., average 4.19 mm. Neill and Rose (1949) reporting on eggs of *D. f. auriculatus,* collected June 16, 1948, in Richmond County, Georgia, give the egg size as averaging 7.7 mm. Their eggs, however, were measured when the embryos were well developed and exhibited spasmodic movements just prior to hatching. The vitelline capsule is immediately against the vitellus in the less developed eggs, but becomes quite apparent at one side as development proceeds, even to the point of appearing as a third distinct envelope. Superficially the egg is similar in its ovoid shape to *D. o. ochraphaeus* as illustrated by Bishop (1941). It is unlike *D. f. fuscus* in having a somewhat larger vitellus and in possessing one less envelope.

Three of the females collected in August still retained some ovarian eggs, the counts being 11, 12, and 26. It was interesting to note that in two of the males opened for positive sexing there were double sets of testes.

MORPHOLOGY

Examination of the series of specimens collected indicates that the population under consideration is of an intergrade nature.

Average size of these specimens was less than previously published data for either *auriculatus* or *brimleyorum.* Total length of all adults averaged 80.03 mm., the range being 59.5 to 91 mm. For males the average was 82.5 mm., range 65.5 to 91 mm.; for females the average was 77.57 mm., range 59.5 to 87.5 mm. Total length of juveniles averaged 48.65 mm., with a range of 32 to 57 mm. Snout to vent measurements were: males 34.5 to 52 mm., average 45.21 mm.; females 34.5 to 53 mm., average 44.71 mm.; average of all adults 44.96 mm.; juveniles 24 to 33 mm., average 28 mm. Tail lengths were relatively short, corresponding more closely to *brimleyorum.* The tail, represented as percent of total length, averaged 42.9% for all adults, 43.4% for males, 42.3% for females, and 46.37% for all juveniles. The largest male had a tail which was 46.7% of total length, and the largest female 46.8%. Head lengths were: females 8 to 12 mm., average 10.28 mm; males 9.5 to 13 mm., average 11.64 mm.; average for all adults 10.96 mm.; juveniles 6 to 8 mm., average 7.2 mm. Head widths were: females 6.5 to 8 mm., average 7.43 mm.; males 6 to 9 mm., average 8 mm.; average for all adults 7.71 mm.; juveniles 4.5 to 6 mm., average 5.15 mm. The mental gland of reproductive males was not evident on any specimen with a snout to vent length of less than 34.5 mm.

Costal grooves were fourteen, rarely fifteen. Fifteen costal grooves were more frequent in juveniles, occurring in three individuals. Of the adults, only one female possessed fifteen costal grooves. Costal folds between appressed

limbs varied from three to five, with four the number in 72% of the series, three in 16%, and five in 12%.

Vomerine teeth exhibited marked variation in numbers, the range overlapping recorded data for both subspecies. Counts for vomerine teeth were: adult males 0 to 5, average 1.28; adult females 0 to 10, average 4.92; juveniles 0 to 6, average 4.37. The variation between the right and left vomerine patches for any given specimen was never more than three. Parasphenoid teeth were in narrow patches, gradually diverging posteriorly. In most instances the two patches were joined anteriorly, but in a few specimens they were separate.

The intergrade nature of these specimens is more evident in the pigmentation of the venter than in any other character. Within the colony are individuals with the dark, heavily pigmented, white flecked belly characteristic of *auriculatus*, as well as individuals with the light, flesh colored venters characteristic of *brimleyorum*. Between the two extremes are individuals with all degrees of variation. This gradation in pigmentation cannot be attributed to age differences for it is seen equally well in adults (Fig. 4) and juveniles (Fig. 2). In general the animals tend to be lighter in color than typical *auriculatus*, but retain more evidently the dorsal russet stripe common to this subspecies. The light mark from the posterior margin of the eye to the angle of the jaw is for the most part less developed than in *auriculatus*, but may range from an almost indistinguishable mark to a quite definite one. Overall the population tends more toward *auriculatus* than *brimleyorum*. This is to be expected in animals from this southern locality. Future collecting by workers in Texas should result in locating more intermediate populations in Angelina, Nacogdoches, San Augustine and Shelby counties. Data derived from study of this population indicate that the ranges of the subspecies *auriculatus* and *brimleyorum* overlap in east-central Texas, and that interbreeding does occur.

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Distribution of Certain Birds in the Southeastern United States

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Introduction

Since the publication of the most recent edition of the *A.O.U. Check List* (1931) and the State bird books of the Southeast, many previously unknown facts about the distribution of birds in this part of the country have come to light. Many of the more recent records have not been published heretofore; others have appeared in journals of local and limited circulation. The present paper combines such records for wider circulation.

The State publications, along with the *Check List*, are taken as the starting point in each state for records appearing herein. No records are quoted from these sources, except in cases where it seems expedient to compare them with more recent data. State lists have been published for Tennessee (Ganier, 1933), North Carolina (Pearson, Brimley, & Brimley, 1942), South Carolina (Wayne, 1910), Mississippi (Coffey, 1936a), Alabama (Howell, 1928), Georgia (Greene, *et al.*, 1945), and Florida (Howell, 1932). Although no reliable list for Virginia has been accessible, and comparisons in that state are difficult, nevertheless certain records in extreme southwestern Virginia appear to be unusual enough to warrant their publication. In addition to these works, certain others were also used only for comparison, rather than as sources for the following records. The excellent work by Burleigh (1944) on the birds of coastal Mississippi, Greene's *Birds of the Lower Florida Keys*, and the second supplement to Wayne's *Birds of South Carolina* are among these; as are the ornithological journals of wide circulation (The Auk, The Wilson Bulletin, the Audubon Magazine and its supplements).

On the contrary, many records are cited below from articles and notes published in *The Migrant*, *The Chat*, *The Oriole*, *The Raven*, and *The Florida Naturalist*. Certain issues of each, however, have been inaccessible, and this may have resulted in the omission of a few records of importance.

Specifically, the intent of this paper is to combine and present records which add to the previous known distribution of any species in the Southeast at any time of the year. These include the first published records for any major part of a state, even though the species may have been recorded previously in surrounding areas. New records for more restricted areas, however, are not included here, as such records belong to discussions of local, rather than geographic, distribution. Exceptions have been made of any records which extend the known distributional limits of the species, or help to establish such limits. Obviously this approach makes it necessary to be arbitrary in some

cases, but does serve as a guide in the selection of those records which best serve the purpose of this article.

The recent data presented below indicate definitely that some species are extending their range (Prairie Horned Lark, Cedar Waxwing, Cowbird), and a few appear to be withdrawing from parts of their range (Baltimore Oriole). In many cases it is uncertain whether a range extension is indicated or whether the occurrence of those species in outlying localities had been overlooked previously. Future investigations may yield clues indicating whether each of these uncertain cases represents a species which is truly spreading or virtually static.

Because many of the records I have cited are not substantiated by specimens, it is thought best to limit the discussion to full species (or hybrids) only, and binomial nomenclature has been employed. In a few instances in which the records are supported by specimens, or field identification of subspecies is possible, the trinomial is used.

"As is inevitably the case when sight records are investigated, some appear to be acceptable whereas others must be rejected. Decisions of this sort are based on such factors as: (1) the probability of the occurrence at the particular time and place; (2) the reputation of the observer for caution and accuracy in field identification, as well as his total experience in the study of birds; 3) recognition on the part of the observer that a given record is unusual, and an accompanying statement that his observation was therefore carefully made" (Stevenson & Stupka, 1948).

In the few cases where no authority is specified for a record, the writer is solely responsible for the identification. Such records have not been published previously. Generally I have given more details for all previously unpublished records.

ACKNOWLEDGMENTS

Almost without exception, those who were called on for help in the preparation of this paper responded quickly, and I wish to extend my sincere thanks to them for such cooperation. Particularly helpful were several letters from Thomas Imhof, of Fairfield, Alabama. He has submitted a list of unpublished records for various parts of Alabama which add considerably to the ornithology of that state. Harry Monk, of Nashville, Tennessee, helped by locating records in back issues of *The Migrant*, as well as by supplying a few of his own unpublished notes.

Others who have submitted unpublished notes are: Howard T. Odum, New Haven, Connecticut; Dr. Walter Spofford, Nashville, Tennessee; Morton Perry, Birmingham, Alabama; Robert Tucker, Hodge, Louisiana; and Dr. Ezda Deviney, Herbert L. Stoddard, and William Cross, Tallahassee, Florida. For their help in supplying back issues of *The Chat* and *The Migrant*, respectively, I wish to state my appreciation to Harry T. Davis, Raleigh, North Carolina, and Albert F. Ganier, Nashville, Tennessee. Ernest Edwards, of Ithaca, New York, helped in locating records and references. Drs. J. M. Odiorne and Jean M. Linsdale read the manuscript and made valuable suggestions.

ANNOTATED LIST

Eared Grebe (*Colymbus nigricollis*).—One collected near Nashville by Grover Cook (Ganier, 1935b) evidently is the only record of this western species in any Southeastern state.

Pied-billed Grebe (*Podilymbus podiceps*).—The first breeding record for Alabama is that of a nest found near Prattville by L. S. Golsan. Other details are not at hand. In

Tennessee, Ganier (1933) mentions the breeding of this grebe only in the western part, but Todd (1944) found a nest near Morrison (central Tennessee), May 1, 1939.

Sooty Shearwater (*Puffinus griseus*).—Weston's report of one seen by Dr. Malcolm A. Jacobson near the Keys, December 29, 1940, seems to be the first winter record for Florida waters (Longstreet, 1947).

Wilson's Petrel (*Oceanites oceanicus*).—Imhof saw 10 of these petrels at Fort Morgan, August 27, 1946. Evidently this is the first published record for Alabama.

White Pelican (*Pelecanus erythrorhynchos*).—The first published record for eastern Tennessee is that of one seen by William Johnson (1935) at Knoxville, May 8, 1935.

Brown Pelican (*Pelecanus occidentalis*).—One seen at Lake Monroe, Union County, June 15, 1939 (Joyner, 1946), is the second record for the interior of North Carolina, and is over 100 miles southwest of the first (in Durham County). The first record for Tennessee and the interior of Mississippi is that of a bird seen by McCamey (1936) at Lakeview (a few miles south of Memphis), May 7, 1936. Another Tennessee record is reported from Norris Lake, June 6, 1937 (Foster, 1937).

European Cormorant (*Phalacrocorax carbo*).—Hebard (1948) saw 6 flying south at Fernandina, December 17, 1947, thus establishing the first Florida record of this bird.

Double-crested Cormorant (*Phalacrocorax auritus*).—John Pond's record of 2 seen in Hardeman County, July 22, 1937 (Calhoun, 1941), appears to be the first summer record for southwestern Tennessee.

Great White Heron (*Ardea occidentalis*).—A sight record at Greensboro, September 6, 1943 (Crawford, 1943), is 45 miles west of Durham, the locality for the first North Carolina record.

American Egret (*Casmerodius albus*).—In the belief that the breeding of this species in north Alabama has not been mentioned in the literature, I submit the following data: For several years this wader has occurred at Decatur in May, and probably earlier in spring. On May 1, 1948, Imhof saw 60 of them and examined "many nests."

Louisiana Heron (*Hydranassa tricolor*).—One seen at Mud Lake, July 18, 1948, by Coffey (1948) provides the first record both for Tennessee and northern Mississippi.

Little Blue Heron (*Florida caerulea*).—Two adults seen by Imhof at Decatur, May 1, 1948, may well have been breeding, as the post-nuptial wanderings of this heron and the American Egret do not usually bring them into north Alabama before late June. All other records so early in the year are in the southern half of the state, where the species is known to breed.

Black-crowned Night Heron (*Nycticorax nycticorax*).—The first published winter record for Tennessee is that of one seen at Clarksville, December 4-19, 1937 (T.O.S. members, 1938).

Yellow-crowned Night Heron (*Nyctanassa violacea*).—Records in the Okefenokee Swamp, January 3, 1943, and February 22, 1945, seem to be the first winter records for Georgia (Hebard, 1945).

American Bittern (*Botaurus lentiginosus*).—The discovery in Grundy County of a nest containing 3 young, May 26,1943, establishes the breeding of this species in Tennessee (Ganier, 1934).

Least Bittern (*Ixobrychus exilis*).—As Howell (1928) cites only one summer record for Alabama (near Montgomery), it seems advisable to place on record the following: 3 pairs breeding in a cattail marsh at Fairfield (near Birmingham), summer of 1947 (*fide* Imhof); one seen at Decatur, June 30, 1943.

Wood Ibis (*Mycteria americana*).—A female taken near Cumberland Gap, June 13, 1932, appears to be the first ever recorded in eastern Tennessee (Ogden, 1933).

White Ibis (*Guara alba*).—One seen near Memphis, September 2, 1935, is the first published record for Tennessee (McCamey, 1935c).

Canada Goose (*Branta canadensis*).—The first nesting record for the Southeast is furnished by the North Carolina Department of Conservation and Development. Several

broods were hatched at Long Creek Lodge (Surry County), in May, 1944 (The Chat, 8: 60).

White-fronted Goose (*Anser albifrons*).—Three seen near Memphis, March 11, 1945, by the Hoyts and Miss James constitute the first record in Tennessee (Hoyt, 1945).

Blue Goose (*Chen caerulescens*).—The first records for the interior of Florida are reported by Cross on Lake Jackson (near Tallahassee), December, 1945, and November 16, 1947 (Stevenson, 1948a). One taken in Cocke County between 1925 and 1930 is the first record for eastern Tennessee (Walker 1935).

Black Duck (*Anas rubripes*).—Prior to 1933, the only summer records of this duck in the Southeast were on the North Carolina coast (Pearson *et al.*, 1942). In that year, however, the writer saw a small flock near McMinnville, Tennessee, August 15, 1933. Furthermore, Walker (1938) reports one seen near Knoxville, July 24 and August 7, 1938.

Howard Odum (1947) gives a summer record for the interior of North Carolina (Raleigh, June 17). Later (by correspondence) he mentions records at Greensboro, by O. H. Paris (August 10, 1947) and by Craft and Medford (August 3, 1947). On none of these occasions was there any definite indication of breeding.

Davis and Johnston (1947) cite the first summer records for Georgia: 2 near Covington, July 17, 1937 (T. D. Burleigh and C. N. Elliott); and 4 near Atlanta, August 3, 1946 (Davis and Johnston).* I saw one at Mooresville, Alabama, May 30, 1944.

Pintail (*Anas acuta*).—One evidently spent the summer of 1939 near Knoxville, Tennessee, where Walker (1939) first saw it on July 14. This record appears to be unique in the Southeast.

Blue-winged Teal (*Anas discors*).—Although the present species may occasionally remain in the South until early June and return in late August, actual breeding records are few. The following may be the only ones for Tennessee: young 4 weeks old captured by Ganier (1935a) in Grundy County, May 26, 1934; nest of 8 eggs found by Todd (1944) at Mt. Pleasant, May 2, 1936.

European Widgeon (*Mareca penelope*).—Witt (1944) reports the first record of this duck for Tennessee—3 birds which he identified near Henderson, February 21, 1944.

Baldpate (*Mareca americana*).—Because of the extreme scarcity of published summer records for the Southeast, recent records may well be restated: A male Baldpate apparently spent the summer of 1945 on a group of small shallow ponds at Saltville, Virginia (Stevenson, 1945b). Howard Odum (1947) cites a summer record (June 14) for Raleigh, North Carolina.

Ring-necked Duck (*Aythya collaris*).—A female, capable of short flights, at least, was seen on a small lake near Tallahassee from May 29 to August 8, 1948 (Stevenson, 1948b). The only previous summer records in Florida (perhaps in the entire Southeast) are of cripples at Orange Lake, near Gainesville (Fla. Bird Life, p. 146).

Greater Scaup (*Aythya marila*).—The only published record for Tennessee is that of a bird collected in Cocke County about 1915 (Walker, 1935).

Lesser Scaup (*Aythya affinis*).—Although the *A.O.U. CheckList* (1931) makes no reference to the breeding or summering of this species in any of the southeastern United States, the more recent bird books for Florida, Georgia, and North Carolina do record such instances. In addition to these records, the species has been found at Cashiers, western North Carolina, July 19 and August 11, 1937 (Stevenson, 1941); and at Lake Purdy (near Birmingham, Alabama), July 3, 1936.

Barrow's Golden-eye (*Glaucionetta islandica*).—The first record for Tennessee, and one of the very few for the South, is that of an individual seen by Dr. Charles F. Pickering at Clarksville, January 21, 1940, during some of the coldest weather ever known in that part of the country (Clebsch, 1940).

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* Three seen by Davis south of Valdosta, August 2, 1947, were not positively distinguished from the Florida Duck (*A. fulvigula*) (*loc. cit.*).

Surf Scoter (*Melanitta perspicillata*).—Three seen by Zapf (1945), Smith, and Crawford at Greensboro, North Carolina, April 29, 1945, constitute the first record for the interior of that state.

American Scoter (*Oidemia nigra*).—One was killed by hunters on Reelfoot Lake, Tennessee, about November 15, 1945 (Pickering, 1945). It appears to be the only published record for the state.

Ruddy Duck (*Oxyura jamaicensis*).—The record of a male and female a mile apart on Lake Munson (near Tallahassee), July 3, 1948 (Stevenson, 1948b), seems to be unique in Florida and the other southeastern United States.

Mississippi Kite (*Ictinia misisippiensis*).—Denton's record at Macon, Georgia, June 18, 1944, probably marks the northwestern breeding limit in that state (Denton, 1944b). A similar extension in its known range in Alabama is found in Imhof's record of one seen at Edgewater (near Birmingham), March 29, 1946. Recognizing this to be an early date, I obtained the details. The bird was seen at a short distance in good light, and the kite-like shape, light head, and dark tail were all noticed.

Goshawk (*Accipiter gentilis*).—Warriner (1942) mentions a record of this large hawk at Corinth, Mississippi, January 19, 1942. Coffey (1936a) had cited no records for that state.

Red-tailed Hawk (*Buteo jamaicensis*).—Although the *A.O.U. Check List* (1931) does not include Mississippi in stating the breeding range of this raptore, more recent information indicates that it summers at least in the northern parts. Coffey (1939b) speaks of finding it in Tishomingo State Park, June 14 and 16, 1939. About 75 miles west of there the writer (1945a) saw it at Oxford, June 10 and 18, 1944. Although there is no evidence of its nesting in that state, the distribution of nesting records in surrounding states indicates that it probably does.

Harlan's Hawk (*Buteo harlani*).—One collected near Rosedale, Mississippi, January 19, 1946, may be the first record for that state (Vaiden, 1948).

Rough-legged Hawk (*Buteo lagopus*).—One seen south of Memphis, November 16, 1937, is at once the first record for Mississippi and for western Tennessee (Whittemore & Simpson, 1937).

Golden Eagle (*Aquila chrysaëtos*).—Greene, *et al.* (1945), in summarizing the Georgia records, refer to this species as of "rare occurrence all over the State at all seasons." The implication is that there are summer records away from the mountain region, but the present writer has not seen such records in print.

Osprey (*Pandion haliaetus*).—Howell (1928) cites only one summer record for the Osprey in the interior of Alabama, this being in the central part. Near Huntsville (190 miles farther north) I saw one flying over Monte Sano on June 14, 1939, but it was not found again during the next few days.

Winter records for the interior, north of Florida, are very few, but Walter Spofford writes that he saw one flying over the edge of Nashville, Tennessee, January 1, 1942. Apparently the same record was published in *The Migrant*, where the date was given as January 7 (Jamison, 1942a).

Caracara (*Polyborus cheriway*).—Two recently published records are over 30 miles farther north than any others in Florida: one seen by Grimes (1944a) at Jacksonville, April 18, 1925; and one by Carbury (1938) at Fernandina, April 2, 1937.

Duck Hawk (*Falco peregrinus*).—As northern Alabama marks the southern breeding limit of this species (east of the Mississippi River Valley), its continued occurrence there is of interest. One was seen at Mentone, on Lookout Mountain, June 11, 1943 (Stevenson, 1943b), and another at Florence, June 29, 1940.

Ruffed Grouse (*Bonasa umbellus*).—Howell (1928) lists no records for Alabama later than 1913, but the natives on Lookout Mountain told me in 1943 that a few of these "pheasants" still persisted there, a few miles southwest of Mentone (Stevenson, 1943b).

Sandhill Crane (*Grus canadensis*).—The fact that the breeding Cranes of Alabama

still occurred near Foley as recently as January 2, 1939 (indicating that some may yet persist), is of general interest. On that date the writer saw a small flock a few miles northeast of the town.

Although there were no Tennessee records of this crane up to 1933, recent issues of *The Migrant* give four: one seen at Chattanooga, June 1, 1935 (Butts, 1936); a flock of 13 at Crab Orchard, March 13, 1939 (Adams, 1939); one taken from a flock of 4 near Shelbyville, August, 1936 (Edney, 1940); and a large flock seen near Knoxville, October 22-24, 1942 (Ijams, 1942).

King Rail (*Rallus elegans*).—Jamison (1942b) reports the first winter record for Tennessee—that of one killed at Nashville, January 2, 1943.

Clapper Rail (*Rallus longirostris*).—One of the most surprising records to have come to my attention is the occurrence of the Florida Clapper Rail (*R. l. scottii*) at Tallahassee, Florida (20 miles inland), in July, 1937. It was found in a pit below a library window and reported to Dr. Ezda Deviney, of the Zoology Department, on July 22. Its emaciated condition indicated that it might have been thus trapped for several days. The skin, now in the Zoology Museum of Florida State University, is of subnormal size (due to the bird's emaciation), but there can be no question regarding the accuracy of Dr. Deviney's identification as to species and subspecies.

Although the *A.O.U. Check List* (1931) gives no records from the interior for any race of the Clapper Rail, there is a record of *R. l. crepitans* in western Virginia (Murray, The Auk, 46: 106-107). Another one (possibly of the same race) was found dead at Raleigh, North Carolina, April 21, 1944 (McCullough, 1944).*

Virginia Rail (*Rallus limicola*).—A specimen from Cocke County represents the first record for eastern Tennessee. The date was not recorded (Walker, 1935).

Yellow Rail (*Coturnicops noveboracensis*).—A specimen taken in Whitfield County, October 6, 1944 (Hamilton, 1945), probably constitutes the first record for northwestern Georgia.

Black Rail (*Laterallus jamaicensis*).—Birds collected near Del Rio, June 10 and 20, 1915, constitute the only records for Tennessee (Walker, 1935).

Purple Gallinule (*Porphyrula martinica*).—Coffey's record of 5 seen at Tupelo on June 19, 1939, establishes the species as a probable breeding bird in northeastern Mississippi (Coffey, 1943). Earlier (1936a) he had indicated the absence of records for that part of the state. Although formerly known to summer only in northwestern Tennessee (Reelfoot Lake), it was later found nesting more than 200 miles farther east, in Grundy County, where a nest of 6 eggs was discovered on May 26, 1934 (Ganier, 1935a).

Florida Gallinule (*Gallinula chloropus*).—Laskey (1939) cites the first three records for central Tennessee. All of these were made near Nashville, one in spring and two in fall.

Coot (*Fulica americana*).—There are no old breeding or summer records for Mississippi and Alabama (Coffey, 1936a; Howell, 1928); and Ganier (1933) mentions Reelfoot Lake as the only breeding locality for Tennessee. More recent records, therefore, are of interest. The first breeding records for Mississippi are cited by Vaiden (1943), at Rosedale. A Coot was seen at Guntersville, Alabama, June 22, 1945; and Walker (1939) found one near Knoxville, Tennessee, July 29, 1939. A pair at Nashville raised a brood of 5 young in the spring of 1947 (The Migrant, 18: 25).

Piping Plover (*Charadrius melodus*).—The first record for Tennessee is that of one seen south of Memphis, May 5, 1935 (Coffey, 1935a). The writer's records at Tuscaloosa, August 3, 1938, and Birmingham, September 13, 1937, are the first for the interior of Alabama.

Semipalmated Plover (*Charadrius hiaticula*).—No published records of this plover's wintering in the interior of the Southeast are available to the writer, but Cross saw an

* The *Audubon Magazine* account of this record (46, sec. 2, p. 102) did not state the locality.

albino on the east side of Lake Jackson (near Tallahassee), Florida, December 28, 1946. Identification was based chiefly on the size, shape, and color of the bill.

Golden Plover (*Pluvialis dominica*).—Two records by Imhof are the first for the interior of Alabama. One was seeen at Camp Sibert (near Attalla) in early October, 1943, and a flock of 39 at Birmingham, March 22, 1947. My record of one seen at Saltville, September 15, 1945 (Stevenson, 1946a), is restated here without exact knowledge of the species' status in southwestern Virginia.

Black-bellied Plover (*Squatorola squatorola*).—One seen by Whittemore (1938) at Mud Lake, near Memphis, September 25, 1938, seems to be the first record for southwestern Tennessee and one of a very few for any part of the state.

Hudsonian Curlew (*Numenius phaeopus*).—One seen south of Memphis by Ganier and Coffey (1934), July 8, 1934, is referred to as the first record for Tennessee.

Willet (*Catoptrophorus semipalmatus*).—A Western Willet (*C. s. inornatus*) taken in Cocke County, Tennessee, in the late summer of 1934, is the first record of any Willet for that state (Walker, 1935). Coffey (1936b) established its presence in western Tennessee when he saw 4 Willets near Memphis, August 23, 1936.

Baird's Sandpiper (*Erolia bairdii*).—The range of this species in its migration (A.O.U. Check List, 1931) seemingly does not include western Virginia, nor can I locate any published records for that part of the state other than my own (1947b): an individual carefully studied at close range at Saltville, September 8, 1946. Concurring with the writer in the identification were Dr. and Mrs. Lee R. Herndon, Dr. and Mrs. Hugo Doob, and Dr. James T. Tanner.

The first Tennessee record of this sandpiper is that of one or more seen near Caryville, August 27-September 9, 1936 (Foster, 1936). I now consider my Alabama record (*cf.* The Auk, 52: 99) doubtful, and there seems to be no satisfactory record for that state.

Red-backed Sandpiper (*Pelidna alpina*).—Records from the interior of the South are few. The writer (1946a) saw one at Saltville, Virginia, October 6, 1945. The first two records for Tennessee are: one near Knoxville, October 4, 1936 (Henry, 1937); and 12 at Mud Lake, Ocotber 23, 1938 (Coffey, 1939a).

Stilt Sandpiper (*Micropalama himantopus*).—The first records for Tennessee are those of Franklin McCamey (1935a, b), near Memphis, August 7 to September 9 (two years).

Western Sandpiper (*Ereunetes maurii*).—The scarcity of published records in the Southeastern interior again prompts mention of more recent data. Single birds were carefully identified at Saltville, Virginia, August 16 and September 8, 1946. Several other experienced observers concurred with my identification of the second bird. One at Birmingham, September 11 and 12, 1935, proves to be the only record for the interior of Alabama.

Records near Memphis in 1935 (August 7-September 8) are the first for Tennessee (McCamey, 1935b). In the northeastern corner of that state, Herndon identified one at Elizabethton, May 2, 1948 (T.O.S. members, 1948a).

Buff-breasted Sandpiper (*Tringites subruficollis*).—Single individuals seen at Tuscaloosa, September 7 and 24, 1938, evidently represent the first occurrence for Alabama. Monroe (1944) reports the first for Tennessee—2 seen near Halls, September 19, 1943.

Hudsonian Godwit (*Limosa haemastica*).—Stimson (1948a) and others established the first record for southern Florida when they saw 6 of these birds near Cape Sable, May 2, 1948. Kyle (1949) reported 9 near Gulfport, April 1, 1948. (For the first state record cf. *Audubon Field Notes*, 2: 72.)

Sanderling (*Crocethia alba*).—Published records for the interior of the southeastern United States are few, and in Alabama non-existent. The writer (1946a, b) has found the species in Virginia at Saltville (September 15, 1945) and Abingdon (May 25, 1946). My Alabama records at Birmingham (September 7-October 3, 1935; May 9, 1936) and Tuscaloosa (August 18, 19, 1939). Imhof also saw one at Birmingham, May 12, 1946.

Avocet (*Recurvirostra americana*).—A record in Knox County, eastern Tennessee, November 7, 1948, is the first for that state (Howell and Meyerriecks, 1948).

Black-necked Stilt (*Himantopus mexicanus*).—Several late spring records in the vicinity of Jacksonville, by Grimes (1944b) and Moffit Howell, from 1935 to 1941, are the most northern for Florida. The actions of a pair seen on July 7, 1937, indicated the likelihood of young nearby.

Red Phalarope (*Phalaropus fulicarius*).—Wray (1947) gives an account of one found dead by Mrs. C. S. Warren at Lenoir, in western North Carolina, January 1, 1947. It is the only record of the species for that state, except in the Coastal Plain.*

Northern Phalarope (*Lobipes lobatus*).—This species, of very rare occurrence in the interior of the Southeast, was carefully identified at close range at Saltville, Virginia, September 15, 1945 (Stevenson, 1946a). Just preceding this date a hurricane had swept up the Atlantic Coast, causing heavy rains even in western Virginia. These conditions may have been influential in this record, as well as those of the Golden Plover and the Sanderling.

Laughing Gull (*Larus atricilla*).—One seen at Reelfoot Lake, August 9, 1938, is referred to by Simpson (1938) as the first for western Tennessee.

Franklin's Gull (*Larus pipixcan*).—One seen by Coffey (1947) at Memphis, November 19 to December 3, 1947, constitutes the first Tennessee record for this species.

Bonaparte's Gull (*Larus philadelphia*).—Records of this gull are few in the Southeastern interior, and Howell (1928) gave none for Alabama. Imhof and others, however, found one on Lake Purdy, near Birmingham, November 16, 1946.

Least Tern (*Sterna albifrons*).—Howell (1928) refers to a single record for the interior of Alabama (near Montgomery). Its appearance in the northern half of the state is established by my records of single individuals at Tuscaloosa on August 18 and 19, 1939, and at Decatur, September 1, 1943.

Although most winter records for Florida (*cf.* Christmas bird counts) are in the southern half of the peninsula, one was seen 120 miles farther north at Jacksonville, December 22, 1939 (Grimes, 1945).

Royal Tern (*Thalasseus maximum*).—The following record appears to be unique in the interior, north of Florida. Denton (1944a) and Fink carefully identified a Royal Tern at Augusta, Georgia, October 28, 1944.

Black Tern (*Chlidonias nigra*).—Although many fall records are listed for the interior of Alabama (Howell, 1928), none are cited for the spring migration. Its scarcity at that season is further exemplified by my failure to find it, except for one occasion when a single bird was seen flying over Oxmoor Lake, near Birmingham, May 2, 1935.

Black Skimmer (*Rhynchops nigra*).—The writer recorded a single bird on the Warrior River, at Tuscaloosa, Alabama, almost 200 miles inland, August 17 and 18, 1939, following a period of very rainy weather and southerly winds. This is the first record for the interior of Alabama and one of the very few for the interior of the South.**

Dovekie (*Plautus alle*).—One seen by Hallman (1940) and J. T. Peterson on St. Andrews Bay, Florida, December 6, 1939, and collected the following day, appears to be the first record for the Gulf of Mexico.

White-crowned Pigeon (*Columba leucocephala*).—One seen on Jupiter Island, Florida, by Mrs. B. G. Dawes and others, during April, 1947, appears to be the most northern record for the state and the only one for the East Coast (Fla. Nat., 21: 77).

Ground Dove (*Columbigallina passerina*).—Records in 1937-39 indicate the regular

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* The account in Audubon Field Notes (1: 128) refers to the bird as the *Northern* Phalarope (*Lobipes lobatus*) and to the date as January 2.

** There are at least two comparable records in the South. Greene, *et al.* (1945) refer to a specimen from Augusta, Georgia, and Ganier (1933) mentions a specimen from Obion County, Tennessee. As is the case with some other marine species, however, the Skimmer frequently occurs inland in parts of the Florida peninsula.

occurrence of this species at Tuscaloosa and Northport, representing a northward extension of 35 miles in its known range in Alabama, except for two accidental records at Leighton. On one occasion young were flushed, evidencing the breeding of the species there. One was seen at Roanoke, in east-central Alabama, June 24, 1939, but it is not known whether the species occurs there regularly.

Burrowing Owl (*Speotyto cunicularia*).—A nesting record (date not stated) west of Brooksville (MacKenzie, 1944) is a 40-mile northwestward extension in the known breeding range of the Florida population.

Saw-whet Owl (*Aegolius acadica*).—Stupka (1946a) has found these little owls throughout the summer in the Great Smoky Mountains, not far from Gatlinburg, Tennessee, a fact which is indicative of their breeeding farther south than is recognized by the *A.O.U. Check List* (1931).

Chuck-will's-widow (*Caprimulgus carolinensis*).—A bird heard by Hebard (1945) in Charlton County, southeastern Georgia, February 28, 1945, probably represents the first winter record for that state, as the spring migration should not begin until two or three weeks later.

Flicker (*Colaptes auratus*).—Although previously having escaped detection on any of the Florida Keys in summer, this woodpecker was found in numbers on some of the upper keys by R. R. Mason (1932), June 12, 1932.

Yellow-bellied Sapsucker (*Sphyrapicus varius*).—Mrs. Charles Neal (1947) has reported the first Georgia breeding record at Tray Gap (3850 feet) on the Towns-White County line. Young were in the nest on June 14 and 23, 1947.

Red-cockaded Woodpecker (*Dendrocopos borealis*).—The paucity of records in northern Alabama (Howell, 1928) prompts my mention of one of these birds seen near Guntersville, 40 miles from other breeding stations, June 22, 1945. The record of 2 seen at Statesville, July 28, 1945 (Anderson, 1945), is 100 miles farther west than other records in that state.

West Mexican Kingbird (*Tyrannus melancholicus*).—One seen by several competent observers 30 miles west of Miami, Florida, March 14, 1942 (Stimson, 1942), may be the first record for the Southeast. Because the bird was not collected, no subspecific identification was made.

Phoebe (*Sayornis phoebe*).—Three unpublished nesting records in Alabama mark the approximate southwestern limits of breeding range in that state: Red Mountain, near Birmingham, young in nest on July 2, 1932; near Jasper, nest with eggs, April 14, 1931; Red Bay, nest containing young, June 14, 1947.

Dreyfoos (1946) mentions having found the species "throughout the summer" of 1945 in the Fort Benning, Georgia, region. Its summering so far south is surprising, especially since Straw (1947) and Pettingell found no indication of Phoebes there in the breeding season of 1946.

Least Flycatcher (*Empidonax minimus*).—Eugene Odum (1947) gives an account of the first authentic breeding record for Georgia. Burleigh and Denton, accompanying Odum, took the nest and collected the adults and young at Clayton, June 9, 1946.

Of my various Alabama sight records supposedly referable to this species, an individual seen at Birmingham, April 30, 1936, was identified beyond any doubt by its song. This is the second positive record for Alabama, and is 100 miles southeast of the locality of the first record (Howell, 1928).

Acadian Flycatcher (*Empidonax virescens*).—Dietrich (1943), Stimson, and Woodmansee identified one of these flycatchers by sight and call notes in Dade County, Florida, January 30 and February 13 and 27, 1943. These appear to be the first winter records for the United States.

Alder Flycatcher (*Empidonax traillii*).—One collected at Memphis by Ganier and Tucker, August 27, 1944, is referred to as the first record for Tennessee (Ganier, 1945). The first for northern Mississippi were collected by Vaiden (1947) at Rosedale in August and September, 1945.

? Flycatcher (*Empidonax* sp.?).—Despite the almost insurmountable difficulties of distinguishing the species in this genus without hearing the songs, a recent occurrence at Tallahassee, Florida, is nevertheless extraordinary enough to be placed on record.

On the morning of January 7, 1948, the writer was attracted by a series of call notes which he could not immediately identify. The use of 10-power field glasses soon revealed an *Epidonax* flycatcher, of which genus there are extremely few winter records in the Southeast. The frequently repeated call note virtually established its identity as a Least Flycatcher (*E. minimus*), as indicated by its short "i" sound. The syllable "whit," of Saunders, Bent, *et al.*, accurately expresses this note to my ears. Having heard the call notes of other Eastern members of the genus, except for the Yellow-bellied Flycatcher (*E. flaviventris*) (reputed to be a two-syllabled note), I am convinced that these species may be distinguished by call notes. At close range (15-30 feet) and in excellent light, all other characters observed seemed to add weight to my first identification: small size; almost constant tail-bobbing and wing-fluttering; lack of any yellow underneath or of green above; brownish lower mandible. The wooded habitat was of a type which the Alder Flycatcher (*E. traillii*) would not be likely to frequent at any time of the year. Only the writer's unfamiliarity with the Western species of *Empidonax* prevents his stating a positive conviction regarding this bird's identity. Unfortunately no gun was available at the time of this observation. When one was finally secured three hours later, the bird could not be found.

Oddly enough, a male Baltimore Oriole (*Icterus galbula*) was seen at close range on the same date and within 200 yards of the same spot. Although two such unusual records on the same day might be a mere coincidence, it seems possible that a tornado a few days earlier, extending as far eastward as Alabama, could have had a bearing on these occurrences. It is equally curious that neither of these two birds was seen before or since January 7.

Prairie Horned Lark (*Eremophila alpestris praticola*).—There is little question but that this plains-loving bird is gradually extending its breeding range eastward. The *A.O.U. Check List* (1931) does not mention Tennessee, Virginia, North Carolina (nor any states farther southeast) in stating its breeding range. As soon afterward as 1933 (Ganier), however, it was considered a breeding bird all across Tennessee, and has nested for several years in parts of Virginia (Murray, The Auk, 51: 380) and North Carolina (Pearson *et al.*, 1942).

The first records of the Horned Lark's summer invasion of Mississippi appear to be that of 4 birds seen by Coffey (1941a) at Holly Springs, May 17, 1941; and a pair at the same place, July 5, 1942 (Tucker, 1942). Warriner (1945) found 40 or 50 at Corinth, July 2 and 3, 1945. It seems not unlikely that the bird breeds in all of the northern tier of counties in that state today.

Following King's record of the breeding of the Prairie Horned Lark at Leighton, Alabama, May 22 and 23, 1942 (McCormack, The Auk: 60: 105), is a record of its summering at Red Bay, 40 miles southwestward. There I found 4 individuals in upland cotton fields within sight of the marker for the Mississippi state line, June 13, 1947. Three of these were singing, the fourth in immature plumage. These two Alabama localities appear to be the farthest southeastward penetration of breeding Horned Larks to date.

Barn Swallow (*Hirundo rustica*).—Recent field work has yielded the first summer records for north-central Alabama and northern Mississippi. The writer saw a pair of Barn Swallows near Athens, Alabama, June 19, 1939. Warriner (1938) and Wright found its nest at Corinth, Mississippi, May 25, 1938; and Coffey saw one near Tunica, June 7, 1942 (Tucker, 1942).

Cliff Swallow (*Petrochelidon pyrrhonota*).—The first two nesting records for Tennessee, at Dover and near Savannah, have been reported by Ganier and Weakley (1936).

American Magpie (*Pica pica*).—Mrs. Dawes (1948) gives an account of a pair of these birds seen on Jupiter Island in early November, 1947. Whether this represents the first valid record for Florida or, like an earlier record, was based on escaped cage birds, apparently has not been determined.

Fish Crow (*Corvus ossifragus*).—Inasmuch as all published records for Alabama are

in the coastal region, the record of a pair of Fish Crows seen and heard at Tuscaloosa, April 27, 1939, extends the range 130 miles northward. This occurrence should probably be regarded as casual unless others from the interior of the state are forthcoming. A comparable record in Georgia is that of one seen by several observers at Athens, April 10, 1947 (Johnston, 1947).

Red-breasted Nuthatch (*Sitta canadensis*).—Grimm (1946) supplies the first published records for the coastal region of Georgia: one seen near Hinesville, March 17, 1942, and another near Fleming, April 1, 1944.

Brown-headed Nuthatch (*Sitta pusilla*).—The northern limit of occurrence in Mississippi is probably marked by its presence at Corinth in March, 1933 (Warriner, 1939).

House Wren (*Troglodytes aëdon*).—Recent summer records for northeastern Tennessee, where the species has appeared within the last 20 years, are cited by Tyler and Lyle (1947) for Shady Valley; by members of the Tennessee Ornithological Society (1942a) for Johnson City; by White (1948) for Greeneville; and by Meyer (1946) for Knoxville. The most southern of these records (at Knoxville) is of a singing bird seen almost daily, May 12-July 4, 1944.

Indicative of a northward spread of winter range into Tennessee are records at Johnson City, December, 1935 (Tyler & Lyle, 1936), and Memphis, one collected by Burdick, December 30, 1941 (T.O.S. members, 1942).

Winter Wren (*Troglodytes troglodytes*).—The records of Ganier and Clebsch (1944; 1946) seems to represent an extension of the breeding range from the Great Smokies southwestward to the Unicoi Mountains.

Bewick's Wren (*Thryomanes bewickii*).—A singing bird found at Northport, Alabama, May 29, 1939, was at the low altitude of 160 feet and near the southwestern breeding limits of *T. b. bewickii*, although Vaiden (1939) speaks of it as a rare breeding bird near Rosedale, Mississippi. My summer record at Roanoke, June, 1939, also warrants mention in view of the lack of published records at that season in east-central Alabama (Howell, 1928) and in the nearby parts of Georgia (Greene, *et al.*, 1945).

Long-billed Marsh Wren (*Telmatodytes palustris*).—One seen by the Meyers near Knoxville, March 21, 1938, may constitute the first winter record for eastern Tennessee (T.O.S. members, 1942a).

Short-billed Marsh Wren (*Cistothorus platensis*).—Although the breeding range, as stated by the *A.O.U. Check List* (1931), extends southeastward to "central Indiana and northern Delaware," there is some evidence that the species breeds much farther south, at least in certain years.

Tennessee ornithologists have found this wren as early in "fall" as August 12, 1933, at Nashville; August 2, 1936, near Memphis; and July 25, 1936, at Clarksville—all about two months in advance of the usual arrival dates in the South. At the last locality dummy nests were found. At Nashville an "examination of two specimens indicated possible breeding." There and at Memphis some of the birds seen in August sang persistently (T.O.S. members, 1942a).

Burleigh (1938) established the summering of this species at Athens, Georgia, where he found one singing as early in summer as June 13, 1928. Others were seen in July and August, and one partially built nest was found. Not having read of these records, the writer was surprised to find singing Short-billed Marsh Wrens on the weed-grown parts of the airport near Northport, Alabama, August 3 (and later), 1939. No evidence on their breeding was found.

Of decided interest in connection with these late summer records is a Michigan breeding record in the month of September (Walkinshaw, The Auk, 53: 86). There is, however, a possibility that most of the foregoing records in the South are the result of an early fall migration due to the drying up of the more northern breeding grounds.

An unusual winter record of this Marsh Wren is that of a few seen at Clarksville, Tennessee, December 27, 1943, and January 1, 1944, by Clebsch (1943b) and others.

Catbird (*Dumetella carolinensis*).—A most unusual and apparently valid winter record is that of one seen at Clarksville, Tennessee, January 16, 1943, by Clebsch

(1943a) and McLaughlin. One on Anastasia Island, July 4, 1932 (Hallman, 1934), may be the only summer record for the east coast of Florida.

Robin (*Turdus migratorius*).—In its southward spread in the breeding season the Robin has evidently invaded at least two new localities in Alabama in rather recent years. It was found to be uncommon at Tuscaloosa in 1938 and 1939; and fairly common throughout my stay at Auburn (early July to mid-September, 1943). Furthermore, at Columbus, Georgia, not far from Auburn, it is also said to breed (Dreyfoos, 1946).

The first summer record for Florida, east of Pensacola, is that of a single bird seen repeatedly in Tallahassee by J. C. Harvin, July 27 through September, 1943. Richard Langston reports having seen a pair on a lawn in nearby Thomasville, Georgia, August 1, 1948 (Stevenson, 1948b).

Cedar Waxwing (*Bombycilla cedrorum*).—Recent breeding records evidence the continued southward spread of this species. Odum (1945b) and Denton found 4 young waxwings and one or 2 adults flocking together at Tate, Georgia, July 29, 1945. The two earlier breeding records are 50 miles northeast, and 55 miles east, of Tate (Greene, *et al.*, 1945).

The first breeding record for Alabama is established by the work of Dr. S. R. Tipton and Morton Perry near Birmingham in 1946. A pair of Waxwings and their nest were seen at Lake Purdy on May 26 and June 8. The nest was in a loblolly pine (*Pinus taeda*), about 30 feet above the ground. There was no other trip to this spot until September 14, on which date the observers found both "adult and young feeding in the vicinity of the nest." A male waxwing was found at Lane Park, several miles from this nesting site, July 13 and 14, but there was no indication that it was nesting. Thomas Imhof, who participated in some of the Birmingham observations of waxwings, saw a pair feeding 4 young out of the nest at Cullman, Alabama, July 3, 1946. The long field experience and painstaking accuracy of these observers leave no room for doubt regarding the correctness of the present observations.

Shrike (*Lanius ludovicianus*).—Howell (1928) gave no early summer (or breeding) records of shrikes for northern Alabama and assumed the species to be absent as a breeding bird in that part of the state. Whether it has spread since that time, or had previously been overlooked, is a matter of conjecture, but it now occurs regularly north to Florence, Decatur, Huntsville, and Gunterville. It has been found in summer at many other localities in north Alabama, and its breeding range might well be stated as "entire state, except in mountains." Although none of these more northern summer records are based on specimens, it seems likely that collecting might reveal the presence of the northern race (*L. l. migrans*) at these localities.

Starling (*Sturnus vulgaris*).—Howell (1932) indicated that the Starling was absent from Florida in the breeding season. It remained for F. M. Weston (The Auk, 49: 386) to report its breeding in the northwestern corner of the state. Later, Grimes (1943) reported its breeding in the northeastern corner, at Jacksonville. It should be stated that the species has also occupied Tallahassee, Crawfordville, and Madison at that season (and probably many other towns across northern Florida) and reached coastal Alabama as early as 1940 (May 28-June 10, at Foley).

Bell's Vireo (*Vireo bellii*).—Although Ganier (1933) gives no records for Tennessee, recent evidence indicates that it breeds rarely in the western third of the state. Coffey (1935b) records its nesting at Memphis in 1935, and he later (1946) reports seeing one at Natchez Trace State Park, July 7, 1946.

The writer (1932) has given an account of the first record of Bell's Vireo in Alabama, one seen at Birmingham, August 19-31, 1932. Its frequent singing aided in my identification.

Yellow-throated Vireo (*Vireo flavifrons*).—Howell (1928) mentions no summer records for extreme southern Alabama, therefore it seems advisable to report one singing at Flomaton, June 11, 1940. This represents a southwestward extension of 30 miles.

Philadelphia Vireo (*Vireo philadelphicus*).—Inasmuch as Howell (1928) knew of this vireo in Alabama only from a record in the northwestern corner, more recent data

should be presented. The writer saw single individuals at Easonville, September 21 and 24, 1936. I have also seen a few at Birmingham in spring, as has Imhof in fall. His record of one a few miles north of Gulf Shores, August 28, 1946, is the only one for the southern part of the state.

Black and White Warbler (*Mniotilta varia*).—According to the range described for Mississippi by Coffey (1936a), the presence of this species at Oxford in May and June, 1944, probably represents a southwestward extension of its known breeding range (Stevenson, 1945a). Also June records at Rosedale (Vaiden, 1947) may extend it even farther in the same direction.

Prothonotary Warbler (*Protonotaria citrea*).—The only record for northeastern Tennessee is that of one seen by Lee R. Herndon (1944) on October 19, 1943, at Elizabethton. Although the late date may throw some doubt on the validity of this record, those who know Dr. Herndon will vouch for his extreme care and caution in field identification.

Swainson's Warbler (*Limnothlypis swainsonii*).—One heard singing at Huntsville, June 16, 1939, is 60 miles east and 180 miles north of other summering localities in Alabama. The first summer records for western North Carolina are at Highlands, June 20 and July 3, 1937 (Stevenson, 1941).

Worm-eating Warbler (*Helmitheros vermivorus*).—Morton Perry writes that he, Branch Howe, and Donald Lee found adults singing and carrying food to 3 young at Camp Andrews, about 10 miles south of Birmingham, July 12, 1941. Perry and Tipton found singing birds here and at another site near Birmingham, July 20, 1946. This is 100 miles southeast of the previously known breeding locality in northern Alabama (Howell, 1928). The regular singing of one on May 7, 1936, at Mitchell Dam, 50 miles south of Birmingham, probably indicated breeding there. A Worm-eater seen near Wildersville, June 6, 1944 (Coffey, 1944), may represent the first early summer record for western Tennessee.

Golden-winged Warbler (*Vermivora chrysoptera*).—Records of adults and young found on Mt. Oglethorpe, May 30 and June 23, 1945, by Odum (1945a & b) and others, extend the known breeding range 20 miles southwestward in Georgia.

Brewster's Warbler (*Vermivora chrysoptera* x *pinus*).—The record of one seen by Tucker (1941b) and Smith at Memphis, August 30, 1941, may be the first for Tennessee.

Orange-crowned Warbler (*Vermivora celata*).—Howell (1928) lists winter records for southern and central Alabama only. A record at Birmingham, December 31, 1939, extends its known range 40 miles northwestward.

Yellow Warbler (*Dendroica petechia*).—Known to be a common summer resident at Birmingham (one nest found) and fairly common at Florence. These localities lie outside the breeding limits indicated by earlier records, although there is an exceptional record at Autaugaville (Howell, 1928). The Florence records are of further interest in connection with the fact that the species is unknown as a nesting bird in nearby Mississippi (Coffey, 1936a). A surprising extension in breeding range was established in Georgia when Denton (1945) collected 2 specimens in breeding condition at Augusta, at an altitude of 130 feet, June 11, 1945. The nearest breeding station is Athens, 100 miles northwestward.

Black-throated Green Warbler (*Dendroica virens*).—Denton and Odum (1945) found an adult feeding 2 young on Pinelog Mountain, Cherokee County, Georgia, July 29, 1945. This locality is 60 miles southeast of the Lookout Mountain breeding station cited by Greene, *et al.* (1945).

A southwestward extension of 20 miles in the known summer range in Alabama is found in the writer's records of this warbler in the hills of Virginia pine (*Pinus virginiana*) and hardwoods in eastern Tuscaloosa County, June 4, 1938, and May 23, 1939.

Cerulean Warbler (*Dendroica cerulea*).—Coffey (1936a) gives no indication of its summering in Mississippi, but Tucker (1941a) and Hill found this species on the Tennessee-Mississippi state line, between North Horn and Mud Lakes (south of Memphis), June 25, 1941.

Blackburnian Warbler (*Dendroica fusca*).—The known breeding range in Georgia was extended 40 miles southwestward to Pickens County by Odum (1945a) and Burleigh, May 29, 1945; and by Odum (1945b), June 23, 1945. A southwestward extension of about 20 miles has been discovered along the Tennessee-North Carolina state line in the breeding of this warbler in the Unicoi Mountains (Ganier & Clebsch, 1944; 1946).

Yellow-throated Warbler (*Dendroica dominica*).—The first summer records for north-central Alabama are near Hartselle, May 29, 1944, and at Guntersville, June 22 and 26, 1945. The nearest breeding stations mentioned by Howell (1928) are over 35 miles east or west of these. It appears likely, on geographical grounds, that some of the breeding Yellow-throated Warblers of northern Alabama should prove to be *D. d. albilora*, but there are no collections to substantiate this supposition.

Pine Warbler (*Dendroica pinus*).—Due to the lack of any published records for northwestern Alabama (Howell, 1928), the presence of Pine Warblers at Florence both in winter (1940-41) and summer should be mentioned. All earlier records were made at least 70 miles farther south or east.

Palm Warbler (*Dendroica palmarum*).—Winter records at Rosedale may indicate the northernmost limit of the species in western Mississippi (Vaiden, 1947).

Louisiana Water-Thrush (*Seiurus motacilla*).—The first summer records for Florida have apparently been made in the last 15 years. C. R. Mason (1935) studied one near Quincy on May 15 and 31, 1935. H. L. Stoddard has sent the following note: "On April 13, 1934, Ludlow Griscom and I located a singing Louisiana Water-Thrush . . . in northern Leon County. . . . Later in the season . . . the singing bird was present, but no nest was ever found."

Oven-bird (*Seiurus aurocapillus*).—Hebard (1945) has shown this species to winter in southeastern Georgia, and Meanley (1945) collected one at Fitzgerald, south-central Georgia, February 11, 1945.

Kentucky Warbler (*Oporornis formosus*).—Although the only published breeding record for Florida is in the extreme northwestern corner (Weston, The Auk, 49: 488), the species summers fairly commonly in the Tallahassee region. Stoddard heard at least 5 singing males on the north side of Lake Iamonia throughout April and May, 1943. The writer has found it here throughout the early summer of 1947 and 1948, singing with great regularity. The most southern of these records is within 3 miles of the Gulf, near Wakulla Beach. Although no nests have been found, there is little question but that the species is a regular breeder here.

Connecticut Warbler (*Oporornis agilis*).—Howell (1928) lists no records for Alabama, but I have seen birds of this species under ideal conditions for observation near Birmingham, May 20, 1936, and May 17, 1940. I have, however, submitted to the *Audubon Magazine* a correction for an earlier sight record at Birmingham, September 5, 1933, which I now feel to be unsatisfactory.

Mourning Warbler (*Oporornis philadelphia*).—My sight record of one at Birmingham, May 24, 1940, appears to be the first for Alabama. As this individual was a male seen at close range, the extensive gray-black of the head, neck, and breast were quite diagnostic.

Yellow-breasted Chat (*Icteria virens*).—Howell (1928) cites summer records south to Autaugaville and Abbeville, Alabama, but there is an unpublished record of one in song at Gulf Shores, Baldwin County (160 miles farther southwest), June 5, 1940. A southward extension of 50 miles in Florida is indicated by the summering of the species on Anastasia Island (St. Johns County) in 1932 and 1933 (Hallman, 1934).

Redstart (*Setophaga ruticilla*).—Coffey (1936a) seemed doubtful regarding the summering of this species in Mississippi, but later (1936b) describes finding it at Tishomingo State Park, in the northeastern corner of the state, June 14 and 15, 1939. About 75 miles farther west, the writer (1945a) found it to be a regular summer resident at Oxford.

Bobolink (*Dolichonyx oryzivorus*).—As there are no published fall records for the interior of Alabama (Howell, 1928), the following are presented: Roanoke, August 22, 1934; Birmingham, September 12, 1937; Easonville, September 18 to October 3, 1936.

Western Meadowlark (*Sturnella neglecta*).—One seen by Burdick (1943) east of Memphis, December 8, 1943, and collected on the 11th, constitutes the first record for Tennessee.

Baltimore Oriole (*Icterus galbula*).—This species is apparently retreating from some of its former breeding range in the Southeast. Howell (1928) lists breeding records for localities extending from northeastern to west-central Alabama (Greensboro). Since 1930, however, I have studied birds at the following localities in that part of the state without having found a Baltimore Oriole in early summer: Jasper, Birmingham, Tuscaloosa, Florence, Decatur, Bridgeport, Huntsville, Monte Sano, Guntersville, Mentone (on Lookout Mountain), and Red Bay. This oriole is also said to have nested at Highlands, North Carolina, up to 1911, but could not be found there in the summers of 1937 and 1941 (Stevenson, 1941).

The first winter record of the Baltimore Oriole in North Carolina is that of 2 seen at Wilmington by Mrs. Appleberry (1946) and Mrs. Scales, February 7, 1946.

Cowbird (*Molothrus ater*).—The southeastern breeding limits at the time of publication of the last *A.O.U. Check List* (1931) were "central Virginia, southeastern Kentucky, [and] central Tennessee." The following recent data show that the species has undoubtedly spread southeastward since then.

Coffey (1936a) added Mississippi to the summer range of the Cowbird, without reference to any particular part of the state. The writer first discovered the species in Alabama at Tuscaloosa, where it occurred throughout the summer of 1938 and 1939. On August 9, 1939, a fledgling was seen taking food proffered by an adult Red-eyed Vireo. Cowbirds were also found in early summer at Decatur, July 6, 1943, and Red Bay, June, 1947.

Burleigh (1936) recorded fledgling Cowbirds in western North Carolina, and, because adults were not found at that time, hypothesized that these young had hatched from eggs laid by adult females during their spring migration. The small flock observed by the writer at Franklin, North Carolina, June 28, 1941, however, contained at least one adult male (Stevenson, 1941), as was also the case with the birds seen at each of the Alabama localities.

The breeding status of this species in upper South Carolina (after 1931) has been reviewed by Hudson and Sherman (The Auk, 53: 311-315). No summer records of adult Cowbirds are mentioned in *Birds of Georgia* (Greene, *et al.*, 1945), but Denton (1946) records both adults and young in July and August, 1943-45, at Augusta, where he found a fresh egg in the nest of an Indigo Bunting (*Passerina cyanea*), July 12, 1945. The collecting of a female at Atlanta, May 18, 1947 (Parks, 1947), probably constitutes a summer record. It was found to be in "full breeding condition."

Thus, within the last 20 years, the Cowbird has extended its breeding range southeastward into Alabama, Georgia, and the Carolinas (and possibly Mississippi).

Scarlet Tanager (*Piranga olivacea*).—One seen at Fort Pierce, January 10, 1938 (Kuerzi & Lewis, 1939), is the more northerly of two winter records in Florida.

Summer Tanager (*Piranga rubra*).—One seen in Coral Gables, Florida, February 14 to 21, 1943 (Woodmansee, 1943), appears to be the first winter record for the Southeastern States.

Rose-breasted Grosbeak (*Pheucticus ludovicianus*).—It seems evident that belated fall migrants of this species occasionally remain well into winter. A male seen at Birmingham, November 28, 1936, appeared to be crippled. Griffin (1940) reports one seen at Atlanta, February 12, 1940, following strong south winds and a nearby tornado. This record is omitted from *Bird of Georgia* (Greene, *et al.*, 1945).

Blue Grosbeak (*Guiraca caerulea*).—Although Howell (1928) gives only one summer record for northern Alabama, this species was later found to be a rare to uncommon summer resident at Florence, Decatur, Huntsville, and Guntersville, and proved common at Red Bay. Until recently there were no published records for eastern Tennessee, but it has now been seen in spring at Elizabethton (Herndon, 1946), Knoxville (T.O.S. members, 1948a), and near Gatlinburg (Stupka, 1946b).

Indigo Bunting (*Passerina cyanea*).—Of the breeding range of this species the *A.O.U. Check List* (1931) states "south to . . . Florida (casually)." Howell (1932) also refers to its scarcity as a breeding bird. Now, however, it is abundant in northern Leon County at least (Stevenson, 1947). Mason (1936) has also written of an increase farther west in the state.

In the Southeast this species is restricted in winter almost entirely to Florida (and may be of only casual occurrence there), yet there is one record as far north as Nashville, Tennessee, December 6-16, 1940 (Laskey, 1941); and another was reported, without comment, from Wilmington, North Carolina, January 28, 1947 (Appleberry, 1947).

Painted Bunting (*Passerina ciris*).—Although unknown in Tennessee prior to 1933 (Ganier), this species is now a regular summer resident at Memphis (Coffey, 1933; 1938; 1941; *et seq.*).

Dickcissel (*Spiza americana*).—As Alabama is on the eastern edge of its regular breeding range, the following recent summer records of the Dickcissel in that state are given: Tuscaloosa (nest with 4 eggs on May 25); Florence (common, June to September, 1940); Decatur (May to July, 1943 and 1944); Huntsville (one, June 16, 1939); Guntersville (few, June 22, 1945); Birmingham (to May 23, 1937). The last record may represent migrants, but the birds appeared to be settled for the season until the high weeds on the Municipal Airport were cut.

Evening Grosbeak (*Hesperiphona vespertina*).—The southward invasion of 1945-46 provided Tennessee with its first records of these birds. Numbers ranging up to 100 or more were seen at Elizabethton between November 22, 1945, and May 4, 1946 (Behrend, 1946; the Behrends, 1945). Tyler and Lyle (1945) saw 4 at Johnson City, January 6, 1946. Hebard (1947) saw a flock in Van Buren County, "February 20, 1936" [=1946?].

Goldfinch (*Spinus tristis*).—The record of one at Abbeville, Alabama, on August 18, 1943, probably represents a breeding-range extension of 100 miles southeastward, as the fall migration does not begin in that state before late October. It was also fairly common at Auburn in July and August of that year.

Two recent summer records of the Goldfinch in Mississippi may extend the known breeding range in that state. The writer (1945) found it to be fairly common at Oxford in June, 1945. Vaiden (1940) has found it east of Grenada (central Mississippi), July 14, 1940. The record of a Goldfinch at Orlando, Florida, July 27, 1937 (Nicholson, 1937), probably should be considered accidental.

White-winged Crossbill (*Loxia leucoptera*).—A most unusual example of a northern species straying far south of its normal winter range is provided by the record of a White-winged Crossbill at Tallahassee, Florida, February 6, 1930. Miss Ezda Deviney saw it at such close range that the crossed mandibles and white wing bars were plainly visible. Considering Dr. Deviney's painstaking accuracy and experience in field work, as well as the distinctive nature of the species in question, the writer can hardly doubt the validity of this record, even though the record otherwise farthest south is at Charleston, South Carolina (Aud. Field Notes, 2: 68).

Towhee (*Pipilo erythrophthalmus*).—Coffey (1941b) demonstrated the spotty summer distribution of the Towhee in Mississippi and western Tennessee. The same situation may prevail in Alabama, where considerable field work failed to reveal its presence at Bridgeport in June, 1940, and at Red Bay, June 12-14, 1947.

Grasshopper Sparrow (*Ammodramus savannarum*).—The first winter records for Tennessee are at Germantown (Burdick, 1942) and Elizabethton (T.O.S. members, 1948b). One found at Knoxville, March 4, 1942 (Meyer, 1942), may also have wintered.

Henslow's Sparrow (*Passerherbulus henslowii*).—Although southwestern Tennessee is considerably south of the known breeding range of this little sparrow, an individual was found singing by the Coffeys near Memphis, August 2, 1936. This date is far in advance of the time of fall migration for the species (Coffey, 1936c).

Cape Sable Seaside Sparrow (*Ammospiza mirabilis*).—After the apparently total disappearance of this species from its only known breeding station (Cape Sable, Monroe County, Florida), Anderson (1942) rediscovered it in Collier County, when 3 singing individuals were heard on June 28, 1942. The species was still present on May 21, 1948 (Stimson, 1948b).

Lark Sparrow (*Chondestes grammacus*).—Additional summer records for northwestern Alabama might well be cited, as Howell (1928) presents only meager distributional data for the state. At least 7 individuals were found near Florence, July 1 and 2, 1940. Single individuals were seen at separate localities near Red Bay, June 13 and 14, 1947. The bird seen on the 13th was carrying food.

Tree Sparrow (*Spizella arborea*).—Previously known to occur only at Corinth, in northeastern Mississippi (Coffey, 1936a), this sparrow was later collected at Rosedale, 160 miles southwestward, April 1, 1938 (Vaiden, 1939).

Chipping Sparrow (*Spizella passerina*).—Prior to 1940 there were no published summer records of the Chippy for coastal Alabama, but in that year I saw a streaked immature south of Lillian (Baldwin County), June 3. Imhof and I saw 4 near Foley, August 31, 1948. This is a southwestward extension of 70 miles.

Field Sparrow (*Spizella pusilla*).—Howell (1932) gives only one summer record for northwestern Florida (west of the Apalachicola River): Pensacola, June 11, 1922 (no evidence of nesting), but on April 26, 1932, I found an old nest containing one addled egg near St. Andrews Bay (90 miles east of Pensacola). A winter record at Cape Sable, February 12, 1938 (Dietrich, 1938), evidently is 60 miles farther south than any other in Florida.

Harris's Sparrow (*Zonotrichia querula*).—Joe Mason (1941) trapped one at Memphis, December 28, 1939, and January 2, 1940. This appears to be the first record for western Tennessee.

Lincoln's Sparrow (*Melospiza lincolnii*).—Although Ganier (1933) made no reference to the wintering of this species in Tennessee, a few have recently been listed on Christmas bird counts at Johnson City, Knoxville, Memphis, and Reelfoot Lake (T.O.S. members, 1936; 1942b; 1944; 1948b). Mrs. Laskey (1943) cites several winter records for Nashville.

To the record cited by Howell (1928) for the spring migration in Alabama (at Florence) may be added other records at the same locality, Tuscaloosa, and Birmingham.

Song Sparrow (*Melospiza melodia*).—Two records in recent years are indicative of the southward spread in the breeding range of this species. Coffey (1942) recorded 6 individuals at low altitudes around Chattanooga, Tennessee, July 21 and 22, 1942; and the Hamiltons (1946) reported that the species had summered "for several years" at Dalton, Georgia, where a nest was found on June 3, 1946.

Lapland Longspur (*Calcarius lapponicus*).—The first records for middle Tennessee are reported by Clebsch (1940), who speaks of seeing the species in numbers at Clarksville, January 28-February 29, 1940. The species may be added to the list of Alabama birds on the strength of a sight record by Imhof at Camp Sibert (near Attalla), January, 1944 (exact date not recorded). Imhof has had previous field experience with this bird on Long Island.

Snow Bunting (*Plectrophenax nivalis*).—The *A.O.U. Check List* (1931) gives no records for the interior of the Southeast, but there are recent records for Tennessee and Alabama. Behrend (1948) saw one Big Bald Mountain, near Erwin, Tennessee, November 21, 1948. During the severe cold of January, 1940, I saw a Snow Bunting at Birmingham, on the 24th (Stevenson, 1943a).

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Breeding Habits of Canada Geese Under Refuge Conditions

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This study of the breeding habits of the Canada goose (*Branta canadensis*) was initiated in the spring of 1944 by the writer and Carlton Beckhart; the writer continued the work from the spring of 1946 to the fall of 1948. Most of the data were obtained on Bright Land Farm near Barrington, Cook County, Illinois, for the period 1944 to 1946, from a flock of 250 birds, of which approximately 25 per cent were full-winged and the remainder wing-clipped or pinioned. Some data were gathered from sources other than Bright Land Farm during the study. Emphasis was placed on the breeding behavior of a goose once mated and then separated from its mate because of death or other reasons.

The birds are held under semi-wild conditions at the farm. They are left almost entirely to themselves and are given little protection; obtaining their own food, except for a very short period during the most severe weather.

During the study period all birds were number-banded; those of known age were color-banded; and mated pairs were banded with coded-color celluloid bands. A number was assigned to each mated pair to record family history. Newly hatched goslings were web-punched if identity was known. All nest sites were numbered and plotted on a map, so that positive identification could be made with a minimum amount of disturbance to the birds.

The study area totals about 420 acres, of which 3 bodies of water cover about 70 acres, with both submerged and emergent aquatic plant life. The adjoining land area of about 350 acres, which is fenced, consists of hay fields, woodlands, and fields of cultivated grains.

The weather included the following Fahrenheit temperature variations during the nesting period: 1944, 27° to 69° with a mean of 42.3°; 1945, 17° to 77° with a mean of 45.8°; 1946, 23° to 77° with a mean of 46.4°.

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MATING

Any bird hatched prior to the nesting season of 1944 was considered an adult. Only a few birds were identified whose ages were known at the period of their first nesting. Birds available for mating and nesting when 2 years old totalled 115 (45 males and 70 females), of which only 9 (7.8 per cent) were observed as nesting for the first time. In addition, during 1948, a male and a female, hatched in 1946, nested with mates of unknown ages within 5 miles of the study area and raised broods of 7 and 6 goslings. Birds available for mating and nesting when 3 years old totalled 134 (52 males and 82 females), of which 27 (20 per cent) were observed as having mated and nested for the first time. It is possible, however, that some may have mated earlier.

The male-female sex ratio for adults when the study was initiated was 79 males to 100 females. For juveniles hatched during the study and raised to banding time (7 to 8 weeks old) the ratio was 92 males to 100 females.

During spring, summer, fall, and part of the winter, the geese usually were scattered on the two lakes and the marsh. In the winter, after the large lake and the marsh froze, most of these birds took refuge on the small oval lake, which was protected on three sides by hills and woodlands. Although this lake froze over, a hole was usually kept open throughout the winter by the activities of waterfowl and possibly springs. In the center of this lake was a large island of willows and goldenrod which offered protection from the weather on all sides. This served as "wintering grounds" and in the summer as a successful nesting area.

It was this diminutive "wintering grounds" where the courtship and pairing was observed. During the study, the writer observed only three cases of courtship, and they all took place on this area. In each case the male performed most of the courtship gestures, which started with the birds as part of the flock, grazing on uncovered vegetation or standing around in a resting cycle. The male, with his head lowered and neck arched, would make sweeping gestures from front to rear and back again, a few inches above the ground and along the side of the female, alternating with his neck extended full length and making a horizontal arc over the back of the female in an effort to isolate her from the flock. If she were reluctant to leave, he would emphasize his desire by delivering light thrusts of his head and bill toward her body, at the same time raising and extending his wings. After the male succeeded in "cutting out" his mate from the flock, and they walked off, he would walk around her several times with head lowered several inches above the ground, uttering a half-call and half-hiss, alternating with the over-the-back gesture of the outstretched neck. This display was repeated a number of times.

The breeding record of 21 mated pairs, in which the age was known for each of the 42 birds, indicated that 12 (57 per cent) of the males were mated with females of the same yearly hatch or age; 2 (9.5 per cent) with females 2 years younger; 3 (14.3 per cent) with females 1 year older; 2 (9.5 per cent) with females 2 years older; 1 (4.7 per cent) with a female 3 years older; and 1 (4.7 per cent) with a female 4 years older.

Particular emphasis was placed on the study of the mating behavior. This

component of the study was carried on for two years to ascertain the breeding behavior of a goose once mated, and then separated from its mate due to death or other causes. Sixteen birds of various ages were involved in the observations and experiments: One male and one female in 1945; seven males and seven females in 1946. They were exposed to diversified conditions, most of which were similar to circumstances in the wild. Artificial and natural methods were employed in the separation of pairs. The variations and the number of birds involved in each phase were as follows:

(1) One bird was placed in a pen on the study area, away from the main flock, but within calling distance. The mate was released, permitting it to travel with the flock. After the nesting and brooding season, the penned bird was released to travel with the flock. Three pairs were used in this experiment.

(2) One bird was removed from the study area and placed in a pen four miles away. The mate was released, permitting it to travel with the flock. After the nesting and brooding season, the penned bird was released on the study area and permitted to travel with the original flock. Four pairs were subjected to the conditions of this experiment.

(3) A bird used in phase (1), that had picked a new mate, later deserted the new mate and then remated with the penned bird (original mate of phase 1) when it was released. The deserted bird was permitted to travel with the flock. One bird was observed under these conditions.

(4) Birds, separated from their mates because of death or disappearance of one of the pair, were allowed to travel with the flock. Ten birds were observed under these conditions.

No data were obtained on the behavior of penned birds that were released after the 1946 nesting and brooding season because of conclusion of the study on the main area.

The case histories of three artificial and one natural separation are recorded in the outlines which follow.

EXPERIMENT 1

A.—In the spring of 1941, male X1M1 and female X1F1 were mated, and they nested. Between 1941 and 1944 the male (X1M1) disappeared.

B.—By the spring of 1944 female X1F1 was mated with male X1M2 and they nested.

C.—On February 18, 1945, these birds, male X1M2 and female X1F1, were used in a mating experiment. The pair was separated, the female being placed in a pen located about 20 feet away from the open territory where the main flock of geese roamed at will. The male (X1M2) was released in the open to be absorbed by the flock. The male returned and talked daily with the penned female for a period of five weeks, after which very little calling was heard from the female, and the male discontinued his visits.

On April 16, 1945, male X1M2 was observed guarding the nest of his new mate, female X1F2. She was incubating four eggs. The eggs were picked up

on May 19, and being past due, were opened and found to contain four dead embryos. This pair was very nervous and would leave their nest and territory very readily.

The penned female (X1F1) was released June 30, 1945 for the purpose of ascertaining what the 1946 nesting season would produce.

D.—Male X1M2 and female X1F1 (original pair in "B") were observed together again March 18, 1946, near the nest site occupied by the male and the new female that he had picked for 1945 ("C"). They were again observed near this nest site on March 23 and 24, 1946. On March 29, 1946, they were again found close to the nest, which contained one egg. The female laid a clutch of five eggs and hatched five. Both birds were very attentive to their nest. This nest was visited approximately 25 times during the incubation period and, without exception, the male was always found within 3 feet of the nest. The excessive amount of fecal material around the nest indicated that he maintained a constant vigil.

In this experiment the male (X1M2) was separated from his female (X1F1) in 1945. He then picked for a new mate female X1F2 when the breeding period arrived. However, when his old mate, female X1F1, was released and available, they remated.

E.—When male X1M2 remated with female X1F1 this left female X1F2 without a mate until she was observed with a different male, X1M3, on March 16, 1946, and again on March 23, 1946. The first egg was found on March 29, and the clutch of five was completed on April 7. She left the nest on May 3 with four live goslings; one having died on the nest.

EXPERIMENT 2

A.—In the spring of 1941 male X2M4 and female X2F3 were mated and they nested.

B.—In the spring of 1944 they were still mated and again nested.

C.—On Ferbuary 18, 1945, this pair was used in another mating experiment by breaking them up and placing the male (X2M4) in a pen about 20 feet away from the open territory of the main flock. The female (X2F3) was released with the main flock and she was immediately absorbed and never returned to the pen site, nor did the male (X2M4) do any calling.

D.—On April 1, 1945, the free female (X2F3) was observed mated with a different male (X2M5) and was sitting on a nest of four eggs. On April 6 she had six eggs and was incubating. On May 2 she left the nest with three young. Of the remaining eggs, one was infertile and two had dead embryos about 22 to 24 days old. This pair protected their territory and nest with violent aggressiveness.

The structure of the nest of this pair was the best of 71 observed during the 1945 nesting season.

The penned male (X2M4) was released in the main flock on June 30, 1945, for the 1946 mating reaction.

E.—On March 12, 1946, the original female (X2F3) was first observed

with her mate of 1945, male X2M5, near their 1945 nest site. They were also observed near the same site, guarding it, on March 13, 15, 20, and 23. On March 24 one egg was in the nest. She completed a clutch of seven eggs April 2, and on April 28 left the nest with four goslings; two eggs having disappeared and one having produced a dead embryo.

F.—The original male (X2M4) was first observed with a new female mate (X2F4) near the nest site territory of his former mate on March 13, 1946, and again on March 15, 23, and 24. On March 26, one egg was found in a new nest 75 feet away. The clutch of seven eggs was completed on April 5, and on May 1 seven eggs hatched.

Although the original male (X2M4) was turned loose in the flock in the summer of 1945, the female remained with her new mate of 1945 again in 1946.

Note that the male, X2M4, with his new mate, picked the nest site next to his former mate (X2F3), the nests being 75 feet apart.

In contrast to the final action of the original pair in Experiment 1, where they remated when available, this pair of Experiment 2 did not remate.

EXPERIMENT 3

A.—In the spring of 1944, male X3M6 and female X3F5 were mated and they nested. In the spring of 1945, still mated, this pair nested again.

B.—In 1946 they were still mated, but were separated on February 23, 1946. The male was held in the pen while the female was released in the flock. The female returned and talked to the male on February 25, 27, 28, March 1 and 16.

Male X3M6 died on March 18 from an unknown cause. The female discontinued the visits to the pen area and was not seen again until March 29, when she was observed grazing about one-eighth mile from the pen area.

She was observed on April 17, mated with male X3M7, and was setting on a nest with one egg. She was again observed on April 26 incubating five eggs; and on May 22 four eggs hatched.

OBSERVATION 1

A.—In the spring of 1945, male O1M8 mated with female O1F6, producing family XX. Male O1M9 mated with female O1F7, and family YY resulted.

B.—In the spring of 1946, family XX was broken up, female O1F6 having disappeared during the winter of 1945-46. Family YY was broken up after male O1M9 died in the fall of 1945.

C.—On March 12, 1946, male O1M8 and female O1F7 were observed traveling as a pair, and there were no other geese in the vicinity. On March 27 the first egg was laid in the nest. On April 2 the female began incubating five eggs. Four eggs were hatched on April 28. The incubation period lasted 26 days.

This observation indicates that the sequence of activities are comparable to conditions in the wild.

Of the 16 birds involved in the mating experiments and observations, two, a male and a female, each mated with a new mate and nested in 1945. Thirteen mated, and 1 remated, of which 12 nested in 1946. In the 1946 group, 4 of the 14 birds paired off, making 2 pairs. One pair was observed nesting successfully, but the location of the other nest, if they nested, was not found. Several nests on the study area were built and the eggs incubated without our knowing the identity of the pairs, and it is possible that they were in this group.

These mating observations and experiments, over a period of two years, resulted in a clear indication that the Canada geese studied will pick new mates if separated from their original mates; the mating usually taking place the next nesting season. In the event that the separation takes place just prior to the nesting season, however, it was found that they will mate the same year.

Although captive birds were used in these observations and experiments, the large positive sample cannot be disregarded entirely. There is reason to believe that birds in the wild, exposed to some of the circumstances of this study, will react in a similar manner. If they do not, what explanation is there for flocks being able to recover, after large numbers of families are broken up under present-day hunting pressures, such as the tremendous hunting pressure upon the Horse Shoe Lake flock of the Mississippi Flyway during the open hunting season?

The following table shows the interval of time between the separation of a pair, the first association with a prospective new mate, and the day the first egg is laid after this association. This short time-interval indicates a strong breeding urge.

TABLE 1.

Pair	Date Separated	1st Egg After New Mating	Time Elapsed (days)
XP1*	Feb. 18, 1945	Apr. 10, 1945	16† 51
XP2*	Feb. 18, 1945	Mar. 26, 1945	36
XP3	Feb. 23, 1946	Apr. 17, 1946	32†† 53
XP4*	Feb. 23, 1946	Apr. 1, 1946**	37
XP5*	Feb. 23, 1946	Apr. 4, 1946	40
XP6	Feb. 23, 1946	Apr. 27, 1946***	63

* The date of laying of the first egg was estimated by using the formula A—(BxC) =X: A—Date when nest first observed, B—Number of eggs found in nest, C—Rate of laying (1.5 days per egg), X—Date first egg laid.

** First observed with new mate as pair Mar. 13, 1946; time elapsed, 18 days.

*** First observed with new mate as pair Mar. 23, 1946; time elapsed, 28 days.

† It is not known whether the male XP1M2 in experiment 1 was courting a different female while he was visiting his penned original mate. His visits to the penned mate continued for 35 days after separation. In event that he did not start courting a different female before deserting the penned bird, only 16 days elapsed from the desertion date and the day he was observed with a new mate that was on a nest containing 1 egg.

†† Experiment 3 presents a condition similar to experiment 1, except that the female X3F5 was the free bird that visited the penned made for 21 days. It is not known whether she was courted or paired with a different gander while making her visits to her original mate. If she was not, then only a period of 32 days lapsed between the observation of her last visit to the penned male and the date she was first observed on a nest containing 1 egg with a new mate guarding her territory.

POLYGAMY

Three cases of polygamy were recorded during the study; one in 1945, and two in 1946. Each male was mated with two females, and in all observations the nesting territories of the two females adjoined. Dual hatchings, in which the eggs were incubated in the nest for the full period by females mated with the same male were not observed.

1.—Male M-13 and female F-11 mated and nested successfully in 1944, when polygamy was not observed. In 1945 female F-11 incubated 3 eggs for 21 days, then deserted her nest; 36 hours later the eggs were picked up and placed in an incubator. They all hatched. The other female, F-12, incubated five eggs and hatched four; one was infertile. Female F-11 laid her first egg 11 days before female F-12 did. The nests were 70 feet apart. The male would alternate his guarding activities by standing close to one nest, and then moving to the other for a while. If disturbed, the male would go to the invaded territory, assuming an offensive position. When the intruder left the territory the male would remain close to the invaded nest site. Ironically, this male lost both his mates; between June 1945 and February 1946 female F-11 disappeared, and on January 9, 1946, female F-12 was found dead.

During the 1946 nesting period this male mated with a different female, F-13. She laid a clutch of seven eggs. Five hatched and two disappeared. Numerous observations were made of this male during 1946, but polygamous associations were not recorded.

2.—Male M-15 and female F-14 mated and nested with success in the 1944 and 1945 nesting periods, and polygamous activities were not observed in either year. During the 1946 nesting season, female F-14 incubated a clutch of eight eggs, of which seven hatched and one was infertile. The other female, F-15, laid three eggs and then was driven from her nest by an invading pair that took over the territory and nest. The three eggs were marked as belonging to female F-15 and were left in the nest. The invading female laid three more eggs and incubated the six for the full period. The eggs of female F-15 hatched two goslings; one embryo being crushed in the shell.

Both females, F-14 and F-15, laid their first egg on the same day. The male always maintained a guard position near the nest of female F-14, and would advance at once to the nest of female F-15 to attack when an intruder approached her territory or nest. After the invader left, he would return to the territory of female F-14. The nests were 45 feet apart.

3.—In 1944, male M-16 and female F-16 were mated and successfully raised a brood. Polygamy was not observed. In 1945 this same pair mated and nested. Again, polygamy was not observed.

During 1946 female F-16 incubated 11 eggs. A clutch this size immediately arouses the suspicion that more than one female contributed eggs to it. In this case the pair was unusually vigorous in defending its nest from approach by the other geese of either sex, so circumstantial evidence would indicate that the clutch was the product of one female, but observations were not continuous enough to prove it. While mated to female F-16, the male

was engaged in a polygamous mating with female F-17. She incubated a clutch of six eggs, of which none hatched although they were all fertile. The nest was 60 feet away from that of female F-16. A review of the pattern of laying of these two females, Table 2, and the date when the eggs of female F-16

TABLE 2.—Laying and hatching record of mates of polygamous male M-16.

	Mar				Apr										May		
	27	29	31	–	1	3	5	6	7	8	9	10	11	30	–	4	8	9
Eggs laid by F-16	1	1	1		1	1	1	1	1		1	1	1					
Eggs laid by F-17						1	1		1	1			1	1				
Hatched-incubator (F-16)																1	1	1
Hatched by F-16														4				
Incubation period						(				26 days				)				
Hatched by F-17										*None*								

started to hatch, indicates that the possibility of female F-17 contributing eggs to this 11-egg clutch is remote. F-16 laid eggs on March 27, 29, 31; April 1, 3, 5, 6, 7, 9, 10, 11. F-17 laid eggs on April 3, 5, 7, 8, 10, and 11. Three of the eggs of F-16 hatched in the incubator on May 4, 8, and 9, and four were hatched in the nest; while all six of the eggs of F-17 failed to hatch.

The male, M-16, would drive off female F-17 if she approached to between 30 and 40 feet of the nest of female F-16. The male was usually found guarding the nest of female F-16. If an intruder approached the nest of female F-17, the male would rush to her territory and drive her to the water, away from the nest, often while she was incubating. He would then step in the nest and stand on the eggs in defense. This was observed on several occasions, and the fact that no eggs hatched in this nest may be chargeable to this behavior.

Several possibilities are worthy of consideration: A. Female F-16 may be responsible for the clutch of 11 eggs. B. The laying pattern of the two geese indicates that the possibility of female F-17 contributing to the 11-egg clutch is remote. C. If female F-16 did not lay the 11 eggs, and female F-17 did not contribute to the clutch, was this gander involved in a polygamous practice with a third female?

The practice of polygamy was observed in only a few instances—3 cases in 141 pairs for the years 1945 and 1946. If the identification of individual birds in the wild were possible, such as the birds of this study, the flock of Canada geese nesting in southeastern Idaho under colony conditions (54 to 66 nests per acre as reported by Williams-Jensen-Nelson in 1948), observations might reveal similar behavior.

DESERTION OF MATE

Of the known nesting pairs, 68 in 1945 and 73 in 1946, only 1 pair was broken up by 1 mate deserting the other. This pair was mated in 1944 and in 1945, and nested successfully in both years. In 1946, for reasons unknown, the male deserted his first mate and mated with another female. They nested

and successfully hatched a brood. The original female was on the area during the nesting season, but was not observed with a new mate. It is the opinion of the writer that the desertion observed in Experiment 1 cannot be classed as a natural desertion, due to circumstances which were controlled by man.

COPULATION

Only two cases of copulation were witnessed on the study area. Both observations were made in the nesting season of 1945. The procedure in one case was as follows: The pair was on a small island; both entered the water, swimming side by side. The female executed a dip or shallow dive, with her head coming above the water, body submerged; at the same instant the male, who was swimming beside her, grasped the back of her head with his bill and mounted. The service lasted about 10 to 15 seconds. This took place during the peak of the laying period.

THE FLOCK SHUFFLE

About two months before the first eggs were found, the flock shuffle (a miniature migration) began. This is a yearly maneuver of the birds. As explained elsewhere in this paper, the flock concentrates on a diminutive "wintering grounds," and each spring the flock performs this miniature migration by moving to the large lake and the marsh for food, territorial investigations, and nestings.

The temperature was about 45° F., and the usual compact flock was starting to open. However, most of the birds ranged as a unit. About a week later the flock broke up into small units. Two weeks later these units started to spread out on the lakes and marsh. After another period of two weeks the final break-up took place. Pairs were traveling alone, roaming and looking over territories; some loafing on sites. At this period the separation of parents and yearlings was starting, with light hazing of the yearlings. After another week, the picking and guarding of territories took place. Serious hazing of the yearlings was in progress, and the final break-up of families was at its peak. This period and procedure of hazing to break family ties was also observed on several occasions with pairs that were full-winged and nesting on marshes off the main study area.

NESTING

Which sex picks the nest site territory? It was possible from the information obtained on mating studies to segregate the following cases:

(1) A female separated from her mate and available for mating, mated with an unknown-breeder (bird not previously recorded as a breeder), and built her nest on top of the nest she incubated the previous year.

(2) A male separated from his mate and available for mating, mated with an unknown-breeder female; she built her nest on top of the nest and territory guarded by the male the previous year.

(3) A male and a female, both separated from their mates and available for mating, mated as a pair. The female built her nest on top of the nest and territory protected by the male the previous year.

In these three cases, all females built their nests on top of the previous year's nest. Unfortunately, this sample of nest site selection is small; two observation indicated that the male picked out the nest site, one observation indicated the female picked it out. Perhaps the male may be a little more persuasive in picking the territory and nest site.

In 1946, 15 out of 41 possibilities occurred for mated pairs to return, claim and defend their 1945 nesting territories, and build their nests. In most cases they built the new nest on top of the old one. In addition, 10 pairs returned and defended territories and nested within 100 feet of their 1945 nest sites. Thirteen pairs nested elsewhere, and three pairs were unobserved during the nesting period.

NESTING SITES AND COVERAGE

The main study area included three bodies of water which were available for nesting. The areas and the coverage are as follows:

(1) The large lake of approximately 50 acres, fed by springs and surface waters, has several islands covered with a thick growth of bog birch, a small area of cattails, and a shoreline with vines, willows and oaks, all of which were utilized. Twenty-six pairs nested in this area in 1945, and 23 pairs in 1946.

(2) An oval lake of about five acres is fed by the overflow of the large lake, farm land run off, and perhaps springs. In the center is an island covered with willows and goldenrod—a very successful nesting ground. The shoreline and associated land offered marsh grass at one end and oak woodland at the other. In 1945 there were 24 nests on the island and 2 on the mainland; in 1946 there were 28 nests on the island and 4 on the mainland.

(3) A marsh of about 15 acres, with water impounded by a dam—the source of water being the overflow of the large and oval lakes and run-off from adjoining farm lands. Coverage was chiefly marsh grass and goldenrod on the numerous small islands. In 1945 there were 15 nests on this marsh, and 18 in 1946.

Seven available cover types were used by the geese in their nest construction, as shown in Table 3.

TABLE 3.—Cover types in which nests were found.

Cover Type	Location	Number of Nests 1945	1946
(A) Cattails	Lake	11	10
(B) Bog Birch	Islands	7	8
(C) Goldenrod	Islands	21	25
Goldenrod-Willow	Islands	2	3
(D) Willow (twigs)	Islands	8	7
Willow (twigs)	Shore Line	6	2
(E) Oak (bark)	Shore Line	3	3
(F) Vines	Shore Line	1	1
(G) Marsh Grass	Marsh Bogs	9	13
Marsh Grass	Swan Nest		1

First choice for a nest site was an area surrounded by water; second choice, shoreline; third, if away from water, next to an old stump or on a bog with an unobstructed view. The shortest distance a nest was found from water was 2½ feet from the center of the nest; the longest, 102 feet; and the majority were within 7 feet.

NEST CONSTRUCTION

All nest building observed was performed by the female. At no time was a male observed aiding in the nest-building activities, although he generally was standing guard close by.

A female may create five or six depressions, apparently by wallowing, as a preliminary to nest building. This procedure of making depressions lasted for periods varying from 1 to 15 days, with 1 exception, before the first egg was laid.

The practice of making dummy nests or depressions was recorded as follows: A depression was made about 10 feet away from a nest on a small island that had been used the year previous. The female was sitting in it and the male was standing close by. Eleven days later the female was working on the original nest and no nest material was found in the first depression. Four days later the pair was observed guarding a second depression, and two days after that they were resting near a third depression. After four more days the female was found covering one egg in the nest used the previous year. A clutch of four eggs was laid. In this instance 21 days elapsed between the day the first depression was observed and the first egg was found in a nest.

At no time during the nest-building period was a goose observed to dig or scratch out a shallow depression for a nest by using her feet. On several occasions females were observed to be digging with their bills in soil, and later, depressions were found on these locations. It was not determined what physical aid is used to make the depression for the nest base.

Usually the *actual* nest building is started one or two days before the first egg is laid. Small quantities of down generally appear when the third egg is laid; the quantity of down gradually increasing until incubation is started. Only one nest, containing two eggs, was observed being incubated without down. This nest was located on an island of bog birch. Shells and membranes were found and examined, giving evidence of a successful hatch. Females were observed by the writer in 1946 working on the building and maintenance of their nests when incubating.

The outside shape of the nest was usually oval, and the inside round. Nest dimensions varied considerably. The largest dimensions were 48 by 48 by 10 inches, with inside dimensions of 11 by 11 by 6 inches. The smallest nest measured had outside dimensions of 17 by 24 by 3 inches, with inside dimensions of 9 by 10 by 2½ inches. The average of measurements from 30 nests was 27 by 31 by 4 inches.

Data gathered on nest sizes constructed by geese of known age may indicate the correlation in the construction of nests in the same area by geese utilizing the same type of coverage. There was insufficient sampling in certain age

groups to warrant conclusions. However, goldenrod was utilized often enough in several age groups to indicate possible trends. The average nest sizes in inches for geese of known age are: Three years, 21 by 22 by 3; four years, 32 by 34 by 3½; five years, 23 by 24 by 5; six years, 28 by 31 by 4½; eight years, 32½ by 35½ by 5.

COLONY NESTING

A large number of the nests were built on the oval island surrounded by a moat of water about 30 feet wide and 6 to 8 feet deep. The island is 726 feet long and 157 feet wide, and is approximately 2.3 acres in area.

In 1945, 24 pairs nested on this island, making about 10 nests to the acre. The shortest distance between nests was 40 feet, and the longest 90 feet. The pairs produced 111 eggs. Clutch sizes ranged from 2 to 6 eggs, and averaged 4.6 eggs. Williams and Marshall (1937) reported 4.8 eggs per clutch for birds in the wild at Bear River, Utah. The hatch was poor, comprising 67 goslings (60 per cent), which included 3 that were hatched under a hen and 4 hatched in an incubator from eggs of deserted nests. Five nests were deserted because of floods, crows, or unknown reasons.

In 1946 the nesting population of the island colony increased to 28 pairs (about 12 nests to the acre), and produced 148 eggs. Clutch sizes were from 3 to 8, one having 11 eggs; the average being 5.3 eggs per clutch. The hatch was 114 goslings (77 per cent), including 3 hatched in an incubator. The average hatch per clutch was 4.1 goslings. One nest was broken up by a pair trying to reclaim their nest site of 1945, and one nest was deserted.

The 1945 failure may have been due partially to flooded conditions and general inclement weather.

The result of two years' observations of this colony nesting indicates that these birds nested in harmony. The colony nesting on this area is in contrast to Johnson's (1947) summary of the flock at Seney National Wildlife Refuge ("Nesting birds cannot be crowded; not more than one nesting pair to each half acre of nesting territory has been found desirable.").

Williams, et al. (1948) recorded the Jensen-Nelson waterfowl breeding report of nesting activities of wild birds in northern Utah and southeastern Idaho as follows: For northern Utah; nesting densities for the better sections of this area are about one goose nest per acre. In contrast, the area in southeastern Idaho is totally different. Nearly all nesting is confined to islands. Islands with an area of one-third of an acre can have 18 to 22 goose nests. This would make 54 to 66 nests per acre. The tendency for geese to nest in the same general section of the marsh has been noted to the extent that they can be said to approach colonial nesting.

DEFENSE OF TERRITORY

Both the male and the female are active in the defense of their territory, assuming the offense in the protection of the area from invaders of either sex. The male undertakes the offense alone, after the female starts to incubate the clutch of eggs. At this time the female usually assumes a defensive position,

standing in the nest, or close by, using the bill and wings to drive off the invader.

LAYING

The nesting season in 1945 began March 24, and was completed by May 25. The starting date was three weeks previous to the 1944 season, which began about April 16.

A total of 325 eggs were counted in this period. The peak of the laying season was the week of April 10 to 16, accounting for 120 eggs. The peak week for hatching was May 1 to 7, during which 16 clutches produced 63 goslings. Several clutches hatched in the latter part of April during a snow storm, which forced the goslings to struggle in two or three inches of snow when leaving the nests.

The nesting season for 1946 opened on March 23, and closed on May 30. A total of 404 eggs was recorded during this period. The peak week for laying was April 7 to 13, when 156 eggs were dropped. The peak period for hatching was the week of May 5 to 11, when 26 clutches produced 123 goslings. Egg laying actually began in several cases before the nest was constructed.

In this study the 1945 nesting period extended 61 days, and the 1946 period was 68 days. Dow (1943), in his studies at Honey Lake Valley, Calif., recorded the period of March 6 to May 10, 1940, for a 65-day nesting period. Williams-Marshall (1937) report the Bear River flock nesting for the period April 3 to June 3, 1937, covering 61 days.

The interval in time between the date a territory was first claimed and guarded, and the date the first egg was laid, varied greatly, but the average time was from 13 to 17 days.

During the laying period of 1946, 27 nests were visited at approximately 6:00 to 7:00 p.m. daily, to record the frequency of occurrence of egg laying. No definite pattern was obtained; however, a study of the rate of laying (Table 4) and the number of days required to complete a clutch indicates that in 9 nests the second egg was laid on the second day, and in 16 nests the second egg was laid on the third day. The average rate of laying was found to be 1.5 days per egg.

A three-day investigation of the time of the day in which laying takes place was conducted in 1946. The evening before the study was to start the nests involved were checked for clutch size and eggs were marked to identify them from newly laid ones. Thereafter, checking was at approximately 6:00 a.m., 12:00 noon, and 6:00 p.m.

Fifty-nine eggs were laid during the study period. The pattern of daily laying was as follows: 6:00 p.m. to 6:00 a.m.—24; 6:00 a.m. to 12:00 noon—17; 12:00 noon to 6:00 p.m.—18. The 6:00 p.m. to 6:00 a.m. period produced slightly more eggs. It is believed, however, that a more accurate survey would be to also check the nests at 12:00 midnight, thereby obtaining data on what laying takes place after sunset and before sunrise. It is clear that laying takes place throughout the 24-hour period.

The factors determining the number of eggs per clutch were not learned.

The weather during 1946 was more moderate at the laying season than that of 1945. What effect this had on the egg production is not definitely known.

In 1945 a total of 67 nests was recorded with a total of 307 eggs, averaging 4.6 eggs per nest. Williams and Marshall (1937) recorded 410 eggs in 84 nests, averaging 4.8 eggs per clutch in the wild at Bear River Refuge. The fewest eggs per clutch was two and the most was eight. Six individual eggs were found and classed as promiscuously laid or renesting attempts. One nest containing 12 eggs was found deserted. The total egg production at the Refuge for 1945 was 325.

TABLE 4.—Rate of laying.

Nest No.	Days to complete clutch										
	1	2	3	4	5	6	7	8	9	10	11
Clutches of 4											
401	1				1		1				1
402	1	1	1		1						
403	1		1	1			1				
Clutches of 5											
501	1		1	1	1	1					
502	1		1		1			1	1		
503	1	1	1		1	1					
504	1	1	1			1	1				
505	1	1		1	1			1			
506	1	1		1		1	1				
507	1	1			1	1		1			
508	1		1		1	1	1				
509	1		1		1	1		1			
510	1	1	1	1			1				
511	1		1			1	1	1			
Clutches of 6											
601	1	1		1	1	1	1				
602	1	1		1		1	1		1		
603	1		1	1	1		1			1	
604	1			1	1	1	1		1		
605	1		1	1		1	1	1			
606	1		1		1	1		1		1	
607	1		1		1	1		1	1		
608	1		1	1	1		1			1	
609	1		1		1	1	1			1	
Clutches of 7											
701	1		1	1	1	1			1	1	
702	1		1		1	1	1	1		1	
703	1		1	1		1	1		1		1
Clutches of 8											
801	1		1	1	1		1	1	1		1

Average rate of laying—1.5 days per egg.

In 1946, 73 nests contained a total of 393 eggs, raising the clutch average to 5.4 eggs. Dow (1943) recorded 215 nests with 1,099 eggs, making an average of 5.1 eggs per clutch. Again, the fewest eggs per nest was two and the most eight. One nest was recorded as containing 11 eggs. This clutch was mentioned earlier in this paper. Eleven individual eggs were picked up and classified as promiscuously laid or renesting attempts. The total egg production for 1946 was 404. Davie (1889) stated that Dr. Merrill found clutches averaging five eggs in the upper Missouri, Yellowstone, and Bighorn River areas. Kortright (1943) reports clutches of 4 to 10, and the average 5 or 6. The frequency of occurrence of clutch sizes for this study during 1945 and 1946 are shown in Table 5.

TABLE 5.—Frequency of occurrence of clutch sizes for 1945 and 1946.

Number of eggs in clutch	Number of nests 1945	1946
11		1
8	1	1
7	5	10
6	13	23
5	14	25
4	18	5
3	12	5
2	4	3

Very little in the literature is available regarding the number of eggs laid at various ages. Ridgway (1895) states that Dutcher visited Captain Lane of Shennecock Bay, L. I., who raised Canada geese, and was told that they did not breed until they were three years old, and they laid four eggs the first season, five the next season, and when older, six or seven. The peak production for the birds studied appears to be when they are eight years old, but the over-all pattern of laying shows little correlation with age (Table 6).

TABLE 6.—Frequency of occurrence of clutch sizes of Canada geese of known age.

Number of eggs laid per clutch.	Age (years) 2	3	4	5	6	7	8	9 or over
8							1	
7				1	1	1	2	1
6	1	1	1	2	6	2	2	
5	1	1	3	2	4	2	2	2
4	1	2		2	1	1		
3				1				1
Total	15	19	21	40	67	33	44	20
Average	5	4.75	5.25	5	5.58	5.5	6.28	5

Three hundred and twenty-five eggs were laid in 1945 and 404 in 1946.

The number of atypical eggs found in the two years were ten, less than 1.4 per cent. Six were found in 1945, three of average size (87.5 x 60 mm.), but pointed at both ends and made up the complete clutch; 2 were undersize, and 1 extra long, 111 x 57 mm. Four were found in 1946, 1 undersize, 71 x 50 mm., 2 extra long, 111 x 61 mm. and 110 x 60 mm., and 1 was of average size but tapered to a point.

RENESTING

The nest of a Whooper Swan (*Cygnus cygnus*), located in a marsh, was taken over by a pair of geese, and a clutch of eggs was being laid, when the swans returned to claim their nest. This resulted in several fights, and the geese were usually driven away. Conditions would alternate, with the swans working on the nest, building it higher, and when they left the territory, the female goose would return and lay another egg with the clutch. Rather than have a complete loss, this clutch of four eggs was picked up and placed in an incubator, from which three live goslings were hatched. One embryo died in the pipping stage.

After removing these eggs, the geese left the territory and the female was found 10 days later covering a clutch of 3 eggs. She laid 3 more in this second nest, and 5 hatched, the 6th embryo having died in the pipping stage. This female laid a total of 10 eggs for the 2 nestings. She laid the first egg of the renesting clutch approximately 5 days after the last egg was laid in the first nesting. Whether the clutch size of a first nesting is usually larger than that of a renesting, cannot be concluded from a single observation.

INCUBATION

Incubation usually starts with the laying of the last egg, and the male would wait around in a guard position from 7 to 20 feet from the nest.

Nests are generally kept in repair by the female while she is incubating. On two occasions an incubating goose was observed by the author in 1946 to stand up in the nest, step over the side, and (without covering the eggs) begin to pick up nest-building material within reach, passing the material back as far as the neck and head would reach to the right and left. After working out 15 or 20 feet, the bird returned to the nest and placed upon it the material within reach, repeating this two or three times in one direction. Three or four paths were formed; then the bird settled down in her nest.

Nest sites are usually kept in a very clean condition. Of 141 nests observed, only one was in an unclean condition because of accumulated fecal matter. The male was responsible for this because of his constant vigil very close to the nest (about three feet). This unusual situation may be the result of separating the bird from its mate the previous year for a mating experiment (Experiment 1) and then allowing them to remate.

If a strong wind was not prevailing, the incubating bird did not face in any particular direction. The author observed the procedure of turning the eggs

in 1946. During this procedure the bird usually completed a circle by changing its position each time. When strong winds and inclement weather prevailed, it was observed that the incubating bird faced toward the wind. No observation was ever made of a bird turning its eggs during unsettled weather conditions. It was found that birds work on the eggs and nest at about 50-minute intervals with the following procedure: The bird stands up in the nest, turns 150° to 180°, rolls the eggs under the front part of the body, sits down, settles into position, and replaces disturbed material. These actions are repeated after the 50-minute interval.

Three cases of chilling of eggs and the effects of the hatchability were recorded in 1945 as follows:

1. A dump nest of 12 eggs, located on a birch bog island, was observed to be unattended for about 48 hours, when it was assumed to be deserted. The prevailing temperatures of the 48 hours prior to picking up the eggs ranged between 32° and 43° F. The eggs were placed in the incubator on April 29. On May 3 one hatched; on May 4 two more hatched; and on May 8 the fourth hatched. The other eight eggs had well-developed, dead embryos.

2. A female was observed leaving her nest and territory, and during the following 36 hours was not seen again. The nest was then classed as deserted. The temperatures recorded for these 36 hours varied from 28° to 55° F. The eggs were picked up and placed in an incubator; 17 days later they hatched and the three goslings were raised to maturity.

3. As a result of heavy rains and a blocked outlet, several nests were flooded on an island nesting site. It was not possible to visit the nests until 24 hours later to attempt salvage work. Four eggs were recovered from one nest, which was exposed to temperatures of from 39° to 71° F., and partial submersion in water part of the time. The temperature of the water was not recorded. The eggs were placed in an incubator and hatched six days later. One gosling died at two weeks of age, and the other three were raised to maturity.

These three cases indicate that Canada goose embryos have the vitality to withstand excessive exposure to normal temperature changes and weather conditions for long periods.

The nest is generally covered by the female each time she leaves it, using down from the nest and nest-building material. The cover material was moved by use of the bill.

No particular time was observed in which the female left her nest to feed and rest.

Several observations were made of incubating geese that left their nests to feed and rest. Upon returning, they would stand in the nest, allowing the water on the feathers to drip on the eggs. Whether this moistening of the eggs aided in successful hatching is not known.

The average incubation temperature of the embryo was found to be 101.3° F.; the average shell temperature 100.4° F.; the average breast temperature of

the incubating goose 101.1° F.; the average maximum temperature reached in the nest 101.5° F. These temperatures are "on the nest" averages.

Of 22 nests, 1 hatched in 25 days, 17 hatched in 26 days, 1 in 26 to 27 days, 2 in 27 days, and 1 in 28 days. The incubation time appears to average 26 days. Dow (1943) reports the periods of 28 days and 33 days for incubation. Miner (1923) reports 28 or 29 days, and Kortright (1943) gives 28 to 30 days for the incubation period.

Since the incubation usually started with the laying of the last egg in the clutch, the eggs on the following day were then considered as being under incubation for one day. This was the basis on which the incubation period was computed.

During the 1945 nesting season a goose was observed incubating for a period of 43 days, after which she abandoned the nest, leaving it well covered. The eggs were found to have partly-developed, dead embryos.

In 1946 one female incubated for 54 days; the incubation ceasing when the nest was destroyed by an unknown agent. After incubating for 39 days the female fed for longer periods each day, and after the 46th day, whenever she was feeding and any other fowl approached the nest territory, she would immediately return and settle down in the nest. About this time the male was not so attentive to his protective obligations. It was observed on daily visits thereafter, that the eggs possessed very little warmth. To be sure the female was still incubating and attending regularly, the observer would uncover the nest after each visit.

Dow (1943) reported a goose that incubated a nest on top of a haystack for 87 days. Miner (1923) reported that one female incubated 4 infertile eggs for 35 days, and the following year the same bird incubated 5 infertile eggs for 49 days.

Foreign objects or atypical eggs, mixed with a clutch of average-size eggs that were under incubation, did not affect the incubation behavior of the female or the success of the hatch. In several nests, a wooden egg was added to the clutch under incubation for the purpose of conducting incubation temperature experiments; the respective hatches were successful. Eggs which had thermocouple wires cemented on the shell and in the air cell with lead wires going out the bottom of the nest, were incubated for the full period of time and produced live, healthy goslings.

In several cases marked eggs found outside of their respective nests, but close by, indicated that it is improbable that a female will roll them back into her nest.

At no time during the study was a female observed incubating a nest other than her own.

It was common for a goose incubating her eggs, upon observing an intruder, to settle deep into the nest, head and neck hanging over the side of the nest, and flat against it or on the ground, making herself as inconspicuous as possible.

During the entire study, only the female was observed incubating the eggs.

HATCHING

In some cases, about 48 to 60 hours before hatching, and before any indication of pipping is visible on the shell, peeping in the egg can be heard. The majority of the pipped eggs found in the cracked stage had the crack to the bottom of the nest. The time of emergence varied from 6 to 24 hours when found in the open pipped stage, and from 24 to 48 hours when the eggs were found in the cracked, pipped stage.

The time required to hatch a complete clutch varied from 8 to 36 hours. On several occasions three or four goslings from a clutch would be hatched, dried, and off the nest and being brooded by the gander, while the female was completing the incubation of the balance of the clutch.

In 1945, 325 eggs were laid, and 124 were hatched in 35 nests; averaging 3.5 goslings per nest. Williams and Marshall (1938) reported an average of 3.9 goslings per nest at Bear River Refuge. Ten eggs were hatched in an incubator, making a total of 134 goslings from the 325 eggs, or a 41 per cent hatch. Seventeen of the goslings were found dead on or near the nest, evidently because of exposure or crushing.

In 1946, 404 eggs were laid—an increase of 24 per cent over 1945. Two hundred and eighty-one eggs were hatched in the 61 nests, averaging 4.6 goslings per nest—an increase of 127 per cent in the number of eggs hatched over that in 1945, and an increase of 31 per cent for the eggs hatched per nest. Sixteen eggs were hatched in an incubator, making a total of 296 goslings from 404 eggs, or 73 per cent. Three goslings were found dead on or near the nest.

Smith (1944) reported observing broods averaging 3.7 goslings on the south coast of James Bay and 3.7 goslings per brood for the east coast, although his guide, George Carey, states that he has seen as many as 6 in a brood.

As far as could be determined, the young were taken to the water within 24 hours after hatching, and on only two occasions, pairs with their brood returned to their nest site to rest or roost for the night.

In 1945, 35 nests were incubated for the full period. Sixteen, or 46 per cent, of the nests were found with unhatched eggs in them after the goose had left the territory. Eleven, or 32 per cent, of the 35 nests had the unhatched eggs covered with nesting material as at mid-incubation period, when the goose leaves the nest for a short time. Two of the nests had nothing but egg shells, indicative of a hatch, and were also covered. One had a dead gosling, which was covered in the same manner as the other covered nests.

In 1946, 61 nests were incubated for the full period. Twenty-six, or 44 per cent, had unhatched eggs left in them. Fourteen, or 23 per cent, of the 61 nests had the unhatched eggs covered as in 1945. No nests with dead goslings or egg shells covered with down were found.

FERTILITY

Fifteen unhatched eggs from the total of 325 eggs laid in 1945 were classified as infertile—about 4.6 per cent.

In 1946, 7 unhatched eggs from a total of 404 laid in that nesting season were classified as infertile—about 1.7 per cent.

Williams and Marshall (1937) reported infertility as being found in about 6 per cent of the eggs laid. Dow (1943) found 16 infertile eggs in 127 nests which produced 697 eggs—about 2.3 per cent.

The following method for determining unhatched eggs for their fertility was used in 1946: Any egg, after being incubated for 26 to 30 days, and upon opening was odorless and found to have the yolk and albumen suspended or intact and not congealed, was assumed to be infertile; any egg that was incubated, and upon opening was found to contain body tissue, or lacking body tissue but having a black watery appearance, congealed yolk resembling cheese or thick cream, albumen watery or congealed, and having an odor, was classified as fertile.

MORTALITY

The 1945 hatch suffered losses due to flood, general inclement weather, perhaps to some activities in establishing nest identification markers, and predators.

For a period of three weeks several excessive rainfalls, followed by heavy snow storms, alternate freezing and thawing, and strong winds, caused much uneasiness among the breeders; especially those having shallow nests in cattails (*Typha latifolia*), and along the shore line, where a number were flooded out and deserted due to strong, washing winds.

The 1946 hatch was favored by much milder weather conditions than the 1945 season.

The high mortality after hatching is due, perhaps, to predators visiting the area, inasmuch as very few dead birds or parts thereof were seen or recovered.

Table 7 summarizes the hatch for the peak years in this study.

TABLE 7.—Summary of the hatchings.

	1944	1945	1946
Eggs laid		325	404
Eggs hatched		134	296
Died pipping		6	11
Died late embryonic stage		18	11
Died early embryonic stage		16	49
Eggs broken		5	8
Eggs infertile		15	7
Miscellaneous		131	22
Died on the nest after hatching		17	3
Juveniles banded	60	23	110
Goslings unaccounted for, fate unknown		94	183

MISCELLANEOUS

Voice.—Three eggs were hatched in an incubator and the goslings hand-reared. Attention was centered upon detecting the change in the voice or call. The first adult call was heard when the goslings were 9 weeks old. For the

next 3 weeks there was a mixture of juvenile and adult calls, but after the geese were 12 weeks old the juvenile call was never heard.

Predators.—Very little predation of nests was experienced during the study. It was concluded from eggs, shells, tracks and droppings found near nest sites, that predators were responsible for the five clutches destroyed in 1945: Raccoons were charged with two; opossums, two; and a crow, one. In addition, 31 eggs disappeared, possibly from predation.

In 1946, 22 eggs disappeared from 12 nests. Only three were chargeable to recognized predation by the crow. The other 19 can be accounted for by predators (including dog and man), breakage, and rolling into the water.

What effects predators had on goslings is not known; the mortality rate was high for young birds. Several times red foxes were observed on the study area. On several occasions hunters, when digging out dens of the red fox in the vicinity of the study area, found skeletons and feathers of the Canada goose.

Identifiaction of Young.—To record pair or family history, which included territorial behavior, nesting, laying, hatching, brooding and habits, a number was assigned to each mated pair. Using the numerals one to four in combinations, when assigning a number to a pair, and then punching the webs (from left to right, dorsal posterior view of bird) of their young, a system of web-punching of newly-hatched goslings, which made it possible to recognize any individual from this stage on as belonging to a family, was established.

Several goslings that had been punched in three or four webs when a day old and then picked up seven or eight weeks later for banding, were found with the holes in the webs healed with considerable non-uniformity. Some holes healed shut showing only scars, some healed showing only small holes, and others had perfectly healed large holes. Several birds were found, each having holes in one web large and healed, while one of the webs in the other foot would have the holes very small and healed, and the web next to it would be healed shut with only a scar.

In spite of the irregularity in the healing of the web, this method of code-punching of the newly-hatched goslings before they leave the nest is believed to be one of the dependable methods of identifying families.

It was observed on a number of occasions that day-old goslings of one pair would associate with, and join other families, deserting their own parents, and it was not uncommon for a pair to relinquish their young without much display of resentment. Web-punching birds after mixing would be of no value for correlating young and old as to individual family history, as a brood might include the young of several families.

If properly spaced, it was possible to punch three holes, each approximately three-sixteenths of an inch in diameter, in each web.

Wing bands were used on adults with some success, but were unsatisfactory for goslings.

Tattooing of the webs was tried on both adults and goslings. The web being black, an attempt was made to use white or yellow ink to produce a visible numeral; the difficulty experienced in this operation was the mixing of blood with the ink when the web was pierced. The tender webs of the young and the inexperience of the writer with the use of the tool were added difficulties which made the method impracticable.

SUMMARY

For purposes of identification all birds were number-banded, color-banded, or banded with coded-color celluloid bands; mated pairs were numbered; and newly hatched goslings were web-punched. Nest sites were numbered and plotted during the study.

Very few captive birds nested when two or three years old. A large per cent of the geese were observed to mate with birds of the same age. Sixteen birds separated from their mates picked new mates. Three cases of polygamy were recorded. Desertion, however, was a rare occurrence.

The selection of the nest site in two cases out of three observed was made by the male. In many cases the nest was built on top of the nest of the previous year, and the male did not participate in the building. When possible, a location surrounded by water was chosen, and a wide variation was noted in nest sizes and material used for building.

Laying starts from 11 to 24 days after the territory is claimed and the nesting period lasts about 60 days. Clutch sizes vary from two to eight eggs, and very little predation was evident to reduce the number. Incubation usually starts with the laying of the last egg. It was found that eggs may be chilled and exposed during incubation for as long as 48 hours without killing the embryo. Nests are usually kept in a clean condition and the male stands guard within a distance of from 7 to 20 feet during incubation and hatching. The longest period of incubation recorded during the period of this report was 54 days.

Hatching requires from 8 to 36 hours for a clutch. Peeping can be heard before the eggs are pipped. The period from pipping to emergence may be from 6 to 48 hours. The goslings are usually taken to the water within 24 hours after hatching, and pairs with a brood seldom return to their nest site. Very few infertile eggs were found after nesting. Unhatched eggs were often covered by the female when the brood left the nest.

The adult call is first heard from the gosling at 9 weeks, and after 12 weeks the juvenile call is never heard.

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Fetal Development of the Northern White-Tailed Deer (Odocoileus virginianus borealis Miller)

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The white-tailed deer is the most important big game mammal in point of numbers in the United States. Jackson (1944: 7) has given an inventory showing a total population for the species (disregarding subspecies) in the United States portion of its range of over 3,800,000 individuals. He listed a deer population in 44 of the 48 states. Thirty-eight had over 5,000, with state populations ranging up to 604,625 for Wisconsin, 734,000 for Minnesota, and 750,000 for Pennsylvania. Such an abundant, wide-ranging, and economically important big-game species is deserving of more biological study than it has received.

Study of the prenatal development of the deer has received little attention in the past. A search of the literature, however, does reveal the names of a few persons who have been interested in this subject. One of the earliest and perhaps the first was William Harvey (1578-1657), famous English anatomist and discoverer of the circulation of the blood. He made observations on two, probably three, kinds of deer, the red deer (*Cervus elaphus*), the roe deer (*Capreolus capreolus*), and the fallow deer (*Dama dama*), as pointed out by Meyer (1936: 110). Harvey dissected these deer in all stages of pregnancy, and studied the various phases of gestation (ibid. 125). He had rather interesting ideas on the subject of fertilization. He regarded the uterine cervix as impenetrable (ibid. 70), and ascribed the principle of generation to a 'contagion' arising from contact with spermatic fluid (ibid. 64), rather than to anything corporeal (ibid. 62-64). Harvey states that he could not find anything in the uterus until six weeks after coitus (ibid. 106), the explanation probably lying in the fact that the ungulate blastocyst is translucent, and also due to the small size of the 'conceptuses' for over four months after copulation (ibid. 109).

T. Bischoff in 1843 carried on the first systematic investigation after Harvey's day (Meyer, 1936: 114). It is interesting to note that he developed a fairly clear picture of the phenomenon known as delayed implantation in the roe deer, which Harvey had not understood.

A study of the development of the white-tailed deer has been done at the New York State Wildlife Research Laboratory at Delmar, and reported by Cheatum and Morton (1942, 1946).

Objective and Materials

The present study stems directly from the work done by Cheatum and Morton, and has been undertaken with the cooperation of the New York Conservation Department, which loaned 76 deer fetuses of undermined age

for this work. Of the 76 specimens, there were 44 single fawns and 16 sets of twins. The specimens were collected from does shot illegally, and those killed on highways, and were turned over to Cheatum at the laboratory at Delmar, the fetuses removed and preserved in 70 per cent alcohol. All specimens used in this investigation were collected in the state of New York. According to Cheatum and Morton (1946: 257), there is a difference between the dates of the breeding seasons in the Adirondacks and in the southern parts of the state. The fact, however, that the material used may include specimens from both areas is not significant, as data pertinent to the thesis is based on the longest body measurement, and not from any special calendar date.

Before proceeding with the methods of investigation, the nature of the material will be more closely defined. The period of prenatal growth in mammals falls naturally into three phases: (a) the period of the ovum, (b) the period of the embryo, and (c) the period of the fetus. While growth is continuous and there is no sharp line of demarcation between the phases, each can be designated according to the growth or development of either tissue or organs, or the individual as a whole (Winters, Green, and Comstock, 1942: 7). A definition of each phase will prove useful.

The period of the ovum is designated as that period from fertilization until implantation or attachment of the blastocyst into the endometrium of the uterine wall (ibid. 7).

The period of the embryo is considered to be the period of organogenesis. The internal changes are accompanied by some changes in external body form. The embryo tends to 'unwrap' itself and assume a C-shape, and finally to straighten itself out (ibid. 7).

The period of the fetus is a period of growth and external differentiation (ibid. 10).

The period of the fetus will be the sole concern of this paper. An analysis of the two earlier periods cannot be made until material from these phases of prenatal life is available for study. It is worthy of note that, although the period of the fetus is concerned mainly with the external differentiation and growth of pre-formed organs, this period occupies a much greater per cent of the gestation period than do either of the other two periods. The gestation period of the sheep is about 150 days, and the period of the fetus begins at approximately 34 days of age (Green and Winters, 1945: 5). This means that in sheep the period of the fetus accounts for 77 per cent of the total gestation. The gestation period of the bovine is about 260 days (Winters, Green, and Comstock, 1942: 44), and the period of the fetus begins at 45 days of age (ibid. 10), thus accounting for 84 per cent of the total gestation period. The gestation period of the deer is about 200 days (Cheatum and Morton, 1946: 256), and evidence indicates that the period of the fetus begins at approximately 37 days of age. This would mean therefore, that in the white-tailed deer the period of the fetus occupies 82 per cent of the total gestation period, and that in covering any aspect of this period, one is dealing with a large proportion of the life spent *in utero*.

According to Green and Winters (1945: 21), the setting of an exact age for the ending of the embryonic period, and hence beginning of the fetal period, is purely an arbitrary, but nevertheless useful, expedient. At 37 days the deer (Plate 1, A) looks much like the earliest fetuses of the sheep (Green and Winters, 1945: 25, Fig. 42) and the bovine (Winters, Green, and Comstock, 1942: 35, Fig. 39). The arbitrary criteria in determining this age, as the onset of the fetal period in the deer, are similar to those used by the aforenamed authors in determining the onset of fetal development in the sheep and bovine. Thus at 37 days the activities of organogenesis are past and future changes in bodily outline will result from variation in actual and relative sizes of organs, and will be mainly due to changes in bulk and density of structure, and at this time the fetus is ready to take on those characters which define it to its species.

The definition of the word 'fetus' being now clearly in mind, the threefold purpose of this paper will be set forth:

1. To relate the available fetuses to a curve of fetal growth established by Cheatum and Morton (1946: 256).

2. To establish criteria in terms of body size and development of external characters of fetuses, which characterize different ages of fetal life.

3. To compare the deer with the sheep and bovine when such comparisons are useful.

PROCEDURE OF INVESTIGATION

Methods and observations.—The immediate procedure of investigation was to take a series of linear and circumferential measurements, and to record the weight of each specimen, on a data sheet. Every specimen was placed in the same position before the measurements were taken, i. e., on the right side, with back along a straight line, and away from the investigator. Care was taken to prevent the head from curling tailwards, and to keep the legs in an extended position. The measurements were taken using bones of the skeleton as reference points. No dissection was done; the bones chosen could be felt easily through the skin. In some cases the measurements are accurate, but in others they can only be approximated. In each case it will be stated which measurements are the most satisfactory. Reference to Fig. 1 will be an aid to the description of the points of measurement.

The following linear measurements were taken with the aid of a pair of steel calipers and a vernier scale.

1. *Crown-rump* (C-R).—This measurement was taken on the young fetuses, up to 64 mm., in which the mesencephalon 'crown' protrudes as a hump. It was taken from the top of the hump to the posterior end of the specimen. The points of reference are only fairly well defined (Fig. 1, A).

2. *Forehead-rump* (F-R).—This measurement can be taken accurately. It was taken from the point of intersection of the coronal and sagittal sutures of the skull, to the tuberosity of the ischium (Fig. 1, B).

3. *Shoulder point to 'pin' bone.*—This is a measure of the body length, and can be taken accurately. It was taken from the metacromion process of the scapula to the tuberosity of the ischium, 'pin' bone (Fig. 1, C).

4. *Shoulder point to hip bone.*—This measurement is very similar to the above and when subtracted from it gives an indication of the growth from the hips to the pins. It is

not strictly accurate as the hips, pins, and shoulder points are not on a straight line. It was taken from the metacromion process of the scapula to the crest of the ilium (Fig. 1, C).

5. *Withers to tail head.*—At very young stages, while the fetus is still C-shaped, these points are rather indefinite, but later they become very definite. This measurement was taken from a point mid-way between the vertebral borders of the two scapulae (withers), to the posterior end of the sacrum, 'tail-head' (Fig. 1, C).

6. *Shoulder breadth.*—This measurement can be taken fairly accurately. It was taken from the metacromion process of the scapular spine on one side, to the same point on the opposite side (Fig. 1, C).

7. *Neck length.*—This measurement was difficult as the points of reference are not too definite. It was taken from the metacromion process of the scapula to the first cervical vertebra, atlas (Fig. 1, C).

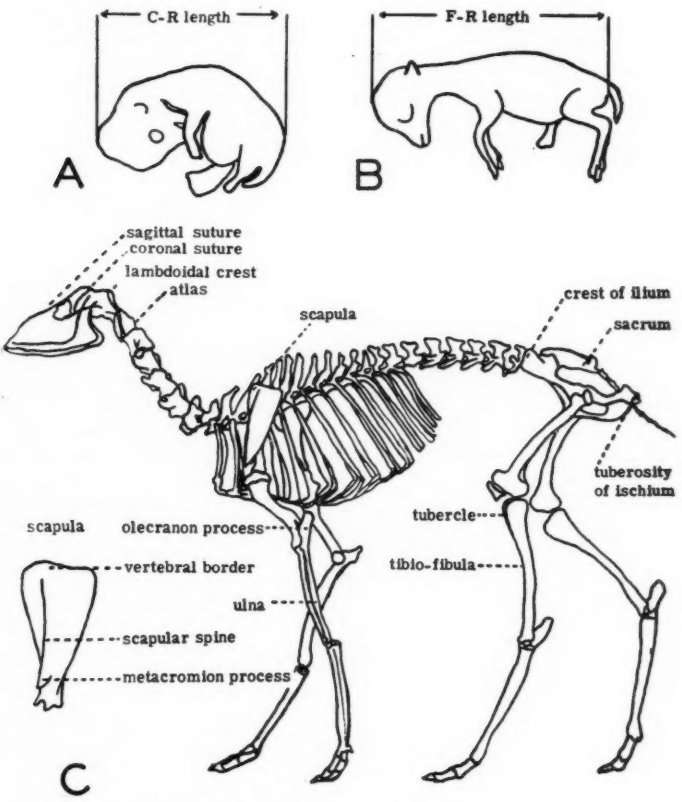

Fig. 1.—Explanation of points of measurement.

8. *Head height.*—This measures the longitudinal axis of the head and is easily taken. It was taken from the lateral side of the incisor teeth to the lambdoidal crest of the skull (Fig. 1, C).

9. *Head breadth.*—This measurement is easily taken by measuring the breadth of the skull just in front of the ears (zygomatic breadth).

10. *Length of forelegs.*—This measurement was taken from the olecranon process of the ulna, to the hoof point. It can be measured accurately (Fig. 1, C).

11. *Length of hind leg.*—This measurement was taken from the tubercle of the tibiofibula, to the hoof point. It can be measured accurately (Fig. 1, C).

The following measurements were taken by placing a fine linen thread around the structure concerned, and then measuring the length of the thread by using calipers and the vernier. The circumferential measurements could be taken fairly accurately in this manner.

12. *Medium neck circumference.*—This measurement was taken at a point mid-way between the metacromion process of the scapula and the first cervical vertebra, atlas (Fig. 1, C).

13. *Chest circumference.*—This measurement was taken back of the forelegs around the deepest part of the chest.

14. *Abdomen circumference.*—This measurement was taken at a point just anterior to the umbilicus.

15. *Horizontal head circumference.*—This is a measure of the circumference of the base of the smooth prominence of the forehead (above the eyebrows and in front of the ears).

16. *Weight.*—The weight was measured in grams and fractions thereof in the early stages, but to the nearest gram towards the end of the fetal period. In order to allow excess preservative fluid to drain off, this measurement was taken last.

Table 1 lists the measurements, taken as described above, of 26 fetuses.

The next step in the analysis was to determine the approximate age of the fetuses, for only in relation to age do the external characteristics have any meaning. The basis for determining the age in days, rests in a normal fetal growth curve for the White-tail, constructed by Cheatum and Morton (1946: 256). This curve was prepared by plotting C-R length (in mm.) in the young fetuses, and F-R length (in mm.) in the older fetuses, with time in days. The twelve specimens used to establish this curve were all of known ages, having been recovered from the does by Caesarian section at known intervals from the date of conception (Cheatum and Morton, 1946: 253-256). The specimens used in the present investigation were related to this curve in the following manner. By taking a point on the ordinate axis of this normal curve, corresponding to the C-R, or F-R, length of a given specimen, and extending a straight line from this point to the curve, the fetus was given a position on the curve of growth of specimens of known age. Next, by dropping a perpendicular to the abscissa from this point on the curve, an approximate age of the fetus could be obtained. Examination of Fig. 2, after Cheatum and Morton (ibid. 256), will show the normal curve to be a slight sigmoid curve. Comparison of this curve with those which have been established for the sheep (Winters and Feuffel, 1936: 13, Fig. 5), and bovine (Winters, Green, and Comstock, 1942:

TABLE 1.—Measurements of deer fetuses by approximate age.

Approx. age of fetus	Weight	*C-R length or F-R length	Shoulder point to pin bone	Shoulder point to hip bone	Withers to tail head	Shoulder breadth	Neck length	Head height	Head breadth	Length of foreleg	Length of hind leg	Medium neck circumference	Chest circumference	Abdomen circumference	Horizontal head circumference
37	0.5	*17.1													
40	0.7	*22.0													
43	1.6	*27.7													
44	1.7	*29.6													
46	2.1	*31.9													
48	2.2	*37.8													
55	4.5	54.4	30.5	23.6	27.6	9	13.3	18.3	9	18	20	18.7	37.8	38.4	39.6
60	7.2	62.7	35.6	30.5	34.3	11.4	14.8	21.7	11.7	20.5	20.7	22.3	46	43.5	44.3
66	14.9	83	45	35.4	45	12.5	15	27.3	12	30.5	30.5	35	59	67	58
75	38.1	113	66.4	54.6	58.3	17.5	31.5	37	18.3	42.3	43.6	41	77	80	75
83	65.5	139.4	81.6	67.3	73.8	20.3	36	47.2	19.6	67.9	67.3	48.9	90	90	82.7
90	90	167.3	98.8	84.1	91.4	23	37	53.3	38	68	69.8	58	103.2	103.2	96.3
94	130.3	180.6	112.8	95.5	94	27	42.3	54.2	27.8	73	73	57.3	116	108.8	107.6
98	185.2	197.2	129.8	102.4	113.4	30	36.8	64.4	29	83.9	98.8	61.5	117.5	118.4	113.3
103	250.8	211	133.2	92.4	116.2	34.4	38	68.7	34.4	100	105.7	78	135	130.5	121.9
107	329.6	224.2	149	116.9	136.7	37.5	45.2	76.7	37.3	106.3	114.5	87	149	147.2	130
110	349.3	233.2	156.4	114.8	132.7	39.8	40.3	83.7	37	115.6	124	82	141	132	142
115	418.7	252	164.6	125.9	139.1	43	53.2	86.4	39.5	125	127	85	153	145	147.7
120	624	268	189	154.4	156.4	53.6	57.7	90.9	41.4	104.9	107.1	99	190.2	179.3	157
125	687.2	284.2	189.2	143.2	162.8	42	56.4	93	43.5	105	105.5	115.7	186	176.7	155.4
135	1029.3	318.5	216	143.4	176.4	49.6	66.7	105	54.6	173	192	133	228	210	188.7
144	1376.4	347	223	155.5	186	67.6	72.5	120.3	56.4	196	203	125	243	230	197
150	1582.5	367	238	168.5	212	78.3	65.7	124.5	60.5	205	215	150	260	245	199.8
159	1578.9	396	265	205	228	77	106.7	127.1	59.6	244	251	150	280	278	222.4
184	2448.8	445	319	200	261	74.1	144.8	134.7	70.3	283	304	185	303	313	220.4
192	2667	459	314	228	276	80.8	91.6	137.5	63.4	300	314	150	310	272	209

43, Fig. 62), reveals that all the graphs are of essentially the same character. This, plus the fact that the original graph was constructed from specimens of known ages leads one to the conclusion that Fig. 2, although based on few specimens, is a valid curve, and that ages of the other specimens calculated by using this graph as a basis are reasonably accurate.

The graph in Fig. 3 was prepared by plotting the F-R length and the weight of specimens whose measurements are given in Table 1. The graph

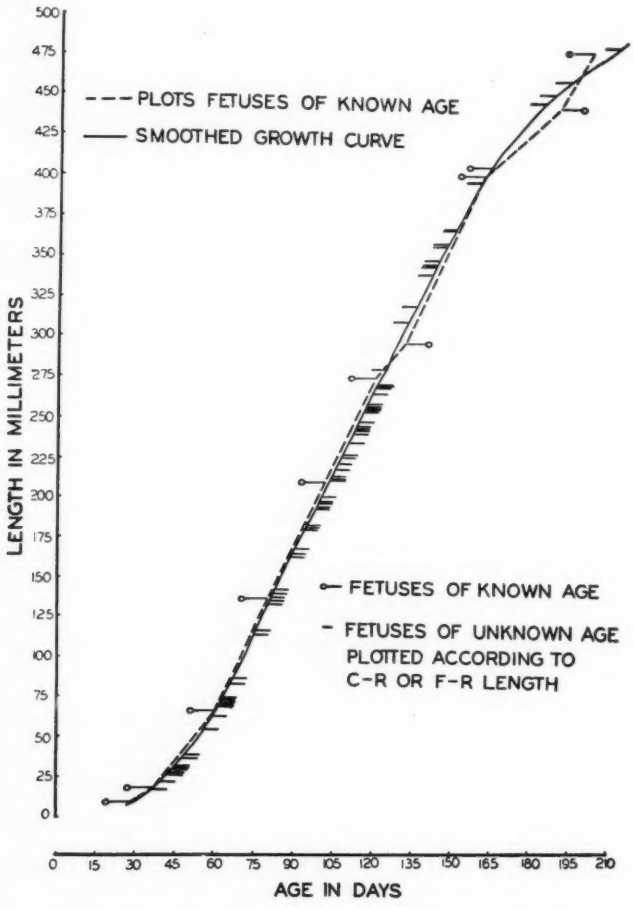

Fig. 2.—Normal growth curve of White-tailed Deer fetuses based on specimens of known age.

was prepared then, using measurements from actual specimens, and since these measurements are definite known quantities, the graph is a valid one. Therefore, if one may state that the graphs presented in Figs. 2 and 3 are valid, for reasons given, one may infer that from these two graphs information regarding length, weight, and age, of any White-tail fetus, may be assembled. The form of the curve in Fig. 3 is similar to one prepared by Winters and Feuffel (1936: 14, Fig. 6), using the same measurements in relation to growth of the sheep fetus.

The ages of the specimens being approximately defined, it was undertaken to establish criteria, in terms of body size and development of external charac-

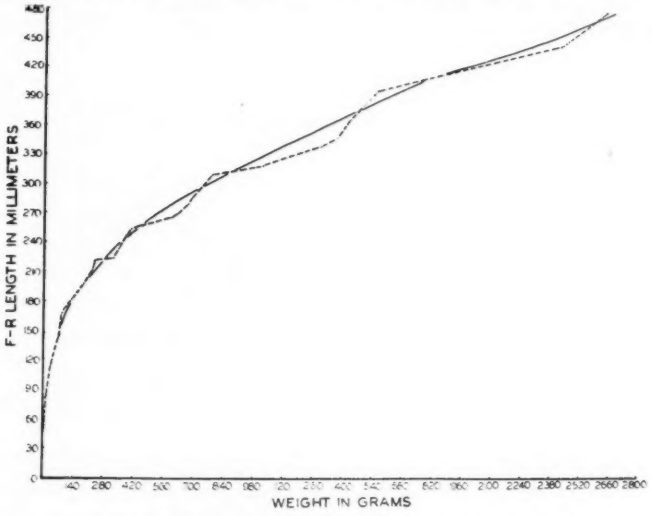

Fig. 3.—Graph plotting F-R (forehead-rump) length in millimeters and weight in grams.

ters, by which the approximate age of a fetus could be derived. As a beginning to establishing these critera, the fetuses were laid out in accordance with their C-R or F-R length, and hence their age, and then examined in succession from the smallest to the largest. It was found that the approximate age of appearance of a character could be determined more accurately when the specimens were studied in this order rather than at random. The fetuses were examined with the aid of a hand lens, and in no case was a character predetermined and then looked for; every character was recorded only when it appeared.

KEY

The data which were accumulated in the manner described above, are presented in the following key. Plates 1, 2, and 3, and Fig. 4 will aid with the description of the characters. When they appear for the first time, characters are in italics.

1. Fetus C-shaped, wrapped around own liver.
   C-R length, 17.1-29.6 mm.; weight, 0.5-1.7 gms.

A. (1) C-R length, 17.1-22 mm., (2) weight, 0.5-0.7 gms., (3) mesencephalon protrudes as a hump (Fig. 4, A), (4) depression overlying pontine flexure obvious (Fig. 4, A), (5) liver a prominent organ, (6) eyelids absent, (7) mouth open, (8) neural arch not completed so nerve cord appears exposed from the medulla oblongata to the posterior end (Fig. 4, A), (9) limb buds only formed, (10) no vibrissae follicles noticeable (Plate 1, A) .....37-40 days.

B. (1) C-R length, 23-29.6 mm., (2) weight, 0.8-1.7 gms., (3) *vibrissae follicles present over eye in position of eyebrow, under eye, on muzzle, between rami of lower jaw, and on cheeks* (Fig. 4, B), (4) *digits differentiated.* Characters 3-8 present as in section 1 A above (Plate 1, B) .....41-44 days.

2. Fetus shaped like a fishhook; angle formed between long axis of body and a straight line drawn from the muzzle through the ear is less than 90°.

C-R length 30-62.7 mm.; weight, 1.8-7.2 gms.

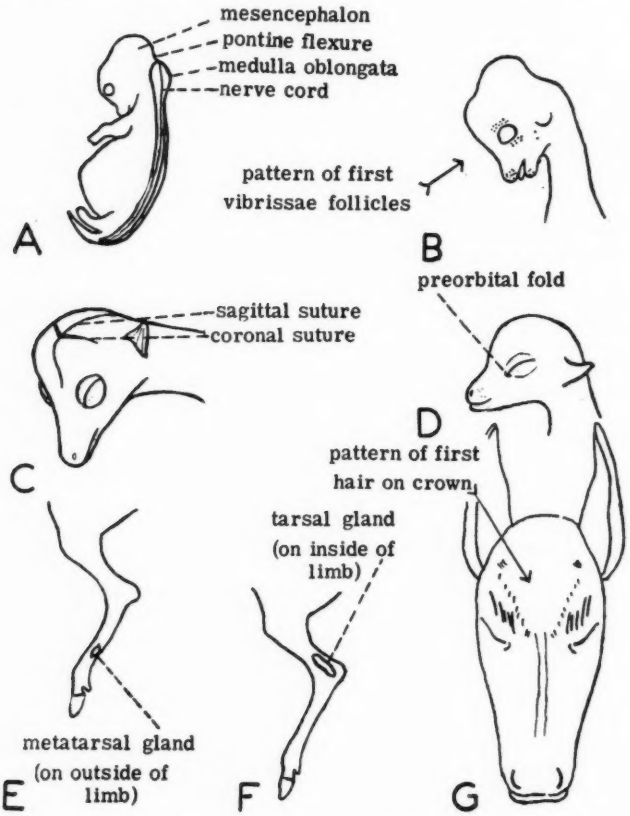

Fig. 4.—Explanation of Key Characters.

A. (1) C-R length, 30-45 mm., (2) weight, 1.8-2.3 gms., (3) *examination by transmitted light shows presence of hemopoietic tissue in long bones of limbs,* (4) *pontine flexure not obvious externally,* (5) mesencephalon protrudes as a hump, (6) liver a prominent organ, (7) eyelids absent, (8) mouth open, (9) neural arch not completed so nerve cord appears exposed from the medulla oblongata to the posterior end, (10) vibrissae follicles present over eye in position of eyebrow, under eye, on muzzle, between rami of lower jaw, and on cheeks (Plate 1, C) ..... 45-52 days.

B. (1) C-R length, 46-62.7 mm., (2) weight, 2.4-7.2 gms., (3) *sagittal and coronal sutures on skull obvious* (Fig. 4, C), (4) *mesencephalon assumes 'normal' proportions,* (5) *cerebral hemispheres (forehead) prominent,* (6) *eyelids formed,* (7) *mouth closed,* (8) *neural arch completed except at posterior end where nerve cord appears exposed.* Characters 3, 4, 6, and 10 present as in section 2 A above ..... 53-60 days.

3. Fetus shaped like an adult; angle formed between long axis of body and a straight line drawn from the muzzle through the ear is equal to or greater than 90°; vibrissae follicles only present.

F-R length, 63-150 mm.; weight, 7.4-77 gms.

A. (1) F-R length, 63-82.5 mm., (2) weight, 7.4-14.8 gms., (3) *sagittal suture on skull prominent,* (4) examination by transmitted light shows presence of hemopoietic tissue in long bones of limbs, (5) cerebral hemispheres (forehead) prominent, (6) liver a prominent organ, (7) vibrissae follicles present over eye in position of eyebrow, under eye, on muzzle, between rami of lower jaw, and on cheeks (Plate 1, D) ..... 61-65 days.

B. (1) F-R length 83-113 mm., (2) weight, 14.9-38.1 gms. (3) *neural arch completely closed,* (4) *preorbital fold at anterior median side of eye* (Fig. 4, D). Characters 3-7 present as in section 3 A above ..... 66-75 days.

C. (1) F-R length, 114-150 mm., (2) weight, 38.2-77 gms., (3) *liver near 'normal' proportions,* (4) *gray pigment appears on top of nose.* Characters 4 and 7 present as in section 3 A above. Characters 3 and 4 present as in section 3 B above (Plate 1, E) ..... 76-85 days.

4. Fetus shaped like an adult; angle formed between long axis of body and a straight line drawn from the muzzle through the ear is equal to or greater than 90°; vibrissae have broken through the skin.

F-R length, 151-233.2 mm.; weight, 77.1-350 gms.

A. (1) F-R length, 151-167.3 mm., (2) weight, 77.1-90 gms., (3) *vibrissae broken through skin over eye in position of eyebrow, under eye, on muzzle, between rami of lower jaw, and on cheeks,* (4) *black pigment on dorsal area of nose,* (5) *brown pigment on anterior surface of nose,* (6) *unpigmented (white) spots on anterior surface of nose,* (7) *cerebral hemispheres (forehead) large,* (8) preorbital fold at anterior median side of eye (Plate 2, F) ..... 86-90 days.

B. (1) F-R length, 168-184 mm., (2) weight, 93-140 gms., (3) *brown pigment on surface of lower lip,* (4) *black pigment along closing surface of eyelids,* (5) *metatarsal gland appears as white oblong spot in metatarsus* (Fig. 4, E). Characters 3-8 present as in section 4 A above ..... 91-95 days.

C. (1) F-R length, 185-222 mm., (2) weight, 141-295 gms., (3) *black pigment appears on hoofs.* Characters 3-8 present as in section 4 A above. Characters 3-5 present as in section 4 B above ..... 96-105 days.

D. (1) F-R length, 223-233.2 mm., (2) weight, 300-350 gms., (3) *cerebral hemispheres (forehead) assumes 'normal' proportions,* (4) *epidermis thick, translucent effect of earlier fetuses is lost* (5) *external nares are open.* Characters 3-8 present as in section 4 A above. Characters 3-5 present as in section 4 B above. Character 3 present as in section 4 C above (Plate 2, G) .... 106-110 days.

5. Fetus shaped like an adult; angle formed between long axis of body and a straight line drawn from the muzzle through the ear is equal to or greater than 90°; light pigment spots visible along the trunk; hair covering incomplete.

F-R length, 235-367 mm.; weight, 352-1582.5 gms.

A. (1) F-R length 235-268 mm., (2) weight, 352-624 gms., (3) *fetus with incomplete hair covering,* (4) *light pigment spots on trunk,* (5) *dark pigment in both sexes on area where horn buds occur in bucks,* (6) *eyelashes are grown,* (7) vibrissae have grown through skin over eye in position of eyebrow, under eye, on muzzle, between rami of lower jaw, and on cheeks, (8) external nares are open, (9) brown pigment on surface of lower lip, (10) black pigment along closing surface of eyelids, (11) black pigment on dorsal area of nose, (12) brown pigment on anterior surface of nose, (13) *unpigmented (white) spots on anterior surface of nose,* (14) metatarsal glands present, (15) black pigment appears on hoofs, (16) preorbital fold at anterior median side of eye .....111-120 days.

B. (1) F-R length, 270-308 mm., (2) weight, 628-840 gms., (3) *hair present on anterior and posterior surfaces of skin covering proximal ends of femur and humerus,* (4) *a line of hair down underside of neck to umbilicus,* (5) *sparse hair covering on tail,* (6) *hair present on front face, dorsal and parallel to eyebrows in a line back to area where (in both sexes) horn buds occur in the bucks* (Fig. 4, G), (7) *fetus with light-colored rump as in adult,* (8) tarsal *glands present* (Fig. 4, F), (9) *crown more darkly pigmented than rest of body.* Characters 3-16 present as in section 5 A above (Plate 2, H) .....121-132 days.

C. (1) F-R length, 309-367 mm., (2) weight, 840.1-1582.5 gms., (3) *row of stiff bristles around top of hoof,* (4) *appearance of hair on the limbs,* (5) hair *on top of crown a golden brown in color,* (6) *hair fairly abundant on the ventral surface, proximal ends of limbs, and on the tail, also a sparse distribution on the dorsal side, not complete and not very thick,* (7) *row of stiff hair around edge of tarsal glands,* (8) *hair appearing in metatarsal glands,* (9) *spots along back of neck fused in a line at least two inches long.* Characters 3, 4, 6, and 8-16 present as in section 5 A above. Characters 7 and 8 present as in section 5 B above (Plate 3, I) .....133-150 days

6. Fetus shaped like an adult; angle formed between long axis of body and a straight line drawn from the muzzle through the ear is equal to or greater than 90°; white spots along the trunk; hair covering complete and thick.

F-R length, 368-480 mm.; weight, 1613.8-2702 gms.

A. (1) F-R length, 368-440 mm., (2) weight, 1613.8-2261 gms., (3) *incisor and canine teeth on lower jaw still partly covered with a membrane,* (4) *hair covering complete and distributed as in adult,* (5) *metatarsal gland with complete hair covering,* (6) *black pigment covers the nose* (Plate 3, J) .....151-180 days

B. (1) F-R length, 441-480 mm., (2) weight, 2430-2702 gms., (3) *incisor and canine teeth of lower jaw entirely bared of their membrane,* (4) *tarsal gland with complete hair covering.* Characters 4-6 present as in section 6 A above .....181-200 days

TWINS

As has already been noted, the materials available for investigation included 16 sets of twin fetuses. The numbers are not sufficient to allow a very thorough study; an attempt was made, however, to draw some comparisons between singleton specimens and specimens of multiple births. In the latter case any

measurements used are the average for the litter. It must be borne in mind that the actual dates of conception for the specimens used in this investigation were not known. As has been explained, the graph in Fig. 2 was constructed from two known quantities, the F-R length and the age in days. This investigator has only one of these quantities known, the F-R length, the age being approximated by a method which has been previously explained. Therefore the sole premise from which investigation can be carried on is from this one known quantity, but since the age can be directly derived from this, it seems legitimate to quote an age for a specimen.

An attempt was made to discover how the rate of development of external characters of twins and singletons compared. If twin A has an F-R length of 115 mm., and a singleton B also has an F-R length equal to 115 mm., then according to the normal growth curve both specimens have been developing for approximately 75 days. If both specimens demonstrate the same 'degree' of development of external characters, then it may be said that the 'rate' of development of external characters in twins and singletons is the same. Such was found to be the case. Singletons have no advantage along this line, over the twins examined.

The weights of two specimens can be compared with the aid of the graph in Fig. 3. From examination of specimens it was found that the singletons were slightly heavier than the twins of the same F-R length.

Since the age can be known only from the F-R length, the statement cannot be reversed, that is, the F-R length cannot be derived from the age. Therefore under the conditions of this experiment one cannot compare the F-R lengths of twins and singletons. It has been found that singleton sheep have no advantage over twins in F-R length (Winters and Feuffel, 1936: 16), and the same may hold true in this case.

SEX DIFFERENCES

The specimens were examined to determine if there were differences in weight or in external characters, according to sex. The ideal state for investigation would have been to have a male and female fetus, and a set of twins from each day of development; however, such was not the case. The data on sex were obscured somewhat by the presence of singles and twins, and the data on singles and twins are obscured by the presence of males and females.

The specimens most valuable in discussing sex differences were eleven sets of mixed twins of different ages, four groups of male and female singles which were the same age, plus six groups in which a singleton of either sex was compared with one member of either sex of a set of twins. From a study of the aforenamed groups it was found that: (a) in nine of the eleven sets of mixed twins the males were slightly heavier than the females; (b) in all four groups of male and female singles the males were heavier; and (c) in the last group it was found that, regardless of the sex of any of the specimens involved, the singletons at comparable ages were the heavier.

It would seem therefore that the males are heavier than the females of the same age, unless one is comparing a female singleton with a male twin, in which case the female is the heavier. In the case of lambs, Winters and Feuffel (1936: 15) state that, whereas unpublished data by Winters showed males to be about eight per cent heavier than females at birth, in their joint study, data indicated weight not to be markedly influenced by sex.

On examination it was found that the degree of development of external characters in the sets of mixed twins, or in males and females of the same age, was the same.

SUMMARY AND CONCLUSIONS

1. Materials for investigation were loaned by the New York State Conservation Department and consisted of 76 white-tailed deer fetuses of undetermined age, collected from does in New York State.

2. The period of the fetus is the sole concern of this paper, as material from the two earlier phases of prenatal life was not available.

3. The period of the fetus occupies 82 per cent of the total gestation period so that in covering any aspect of this period, one is dealing with a large proportion of the life spent *in utero*.

4. Study procedure first involved taking a series of linear and circumferential measurements. The points of measurements are given in Fig. 1, and the results of measurements on 26 fetuses are given in Table 1.

5. Cheatum and Morton have constructed a normal growth curve for the white-tailed deer from specimens of known age, as shown in Fig. 2. The curve is probably a valid one.

6. The specimens used in this investigation were related to the graph in Fig. 2 and an approximate age derived.

7. A graph plotting F-R length and weight (Fig. 3) was constructed for the specimens of unknown age. Since the graph was prepared from two known quantities it is probably a valid one.

8. The characters which confine a specimen to a certain age are presented in key form. Plates 1, 2, and 3, and Fig. 4 will aid with the description of the characters.

9. From a study of the 16 available sets of twins it was found that: (a) the rate of development of external characteristics of twins and singles is the same; (b) singles are slightly heavier than twins of the same age; and (c) under the conditions of this experiment one cannot compare the F-R lengths of singles and twin sets of deer fetuses, but it has been found that singleton sheep have no advantage over twins of the same age in F-R length. The same may hold true in white-tailed deer.

10. From a study of the sets of mixed twins, and male and female singles of the same age, available for this study, it was found that the males were

heavier than the females. A singleton of either sex, however, is heavier than one member of a set of twins of either sex.

11. The degree of development of external characters in the sets of mixed twins, or in males and females of the same age, was found to be the same.

ACKNOWLEDGEMENTS

The author is indebted to the New York State Conservation Department for the loan of the deer fetuses used in this study, and to Dr. E. L. Cheatum, of that department's Wildlife Research Laboratory, for suggestions pertaining to this problem; also to Dr. R. S. Palmer, formerly of the Conservation Division, Vassar College, under whose direction this study was done as a Master's thesis, for his assistance in various ways, including the making of the photographic illustrations.

NOTE.—Since Miss Armstrong's manuscript was completed I have had an opportunity to try out her key on a series of fetuses of known age, obtained by Caesarean or by sacrifice of the parent, at the New York State Conservation Department's Wildlife Research Laboratory at Delmar, New York. In this test no attention was paid to the sex of the fetuses; both were represented. All specimens were keyed out without knowing their age, then the age arrived at by use of the key was compared with the Laboratory's records for the specimens. Following are the ages in days arrived at by using the key, and in parentheses, the actual ages of the fetuses: 41 (44), 43 (47), 48 (50—triplets), 61 (59), 60 (61), 67 (65), 70 (68—twins), 70 (70), 71 (72), 74 (73), 76 (75-76—twins), 78 (76—twins), 80 (80), 83-84 (81), 84-85 (84), 91 (95), 93 (94), 95 (110—a desiccated specimen), 94-95 (96-98), 99 (96-98), 99-100 (103), 100 (103), 103 (103), 110-111 (108), 113 (113), 120 (122), 120 (127), 122 (125), 127 (131), 131 (131), 132 (143), 152-155 (164), 155 (161).

This test reveals that the key works well and that one can interpolate within the time spans given in it. I noted that the development of the hair covering comes a little later than the key implies; that is, in those sections where it is referred to, it applies most accurately to the oldest day of the age span involved or to the beginning of the next one.

When more material for later stages is available, probably the time after 120 days can be further subdivided. This might be accomplished by using, as an additional key character, length of hind leg (as defined in this paper). Then the ages of such fetuses probably could be determined by key to within five days in most cases. Size at birth is a function of the length of time the fetus or fetuses are carried; i. e., if parturition occurs at 189 days the fawn is not as large as if carried 210 days—these being the known extremes. (The usual period is 196 days, or seven lunar months.)

Thanks are due to Dr. E. L. Cheatum for the privilege of examining this series of specimens of known age and for his constructive comments on this note—RALPH S. PALMER, New York State Museum, Albany 1.

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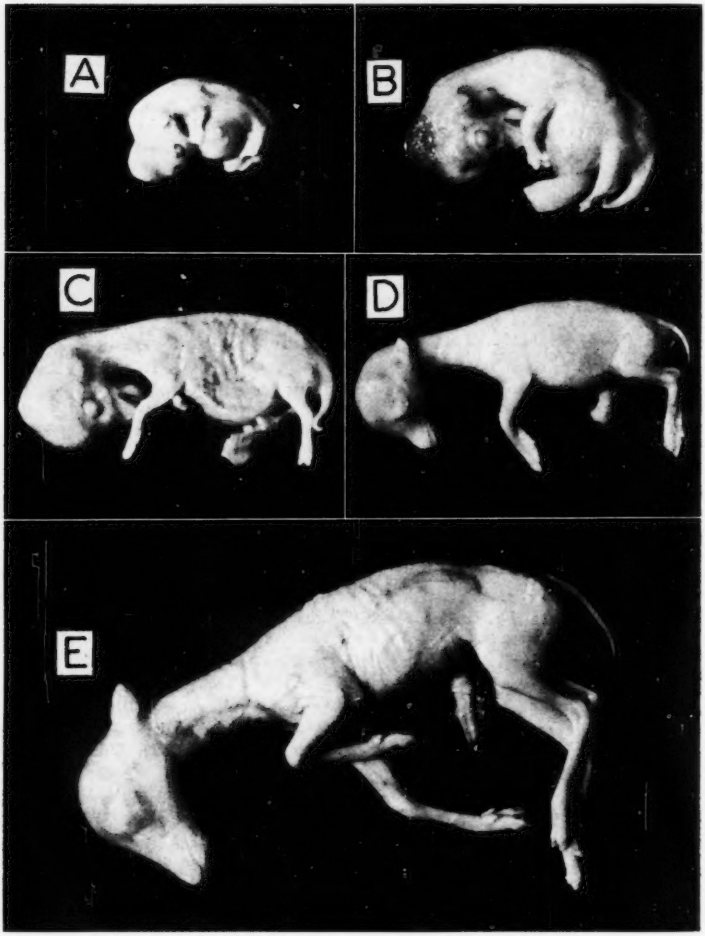

Plate 1.—Fetuses of approximate age in days: A, 37; B, 43; C, 48; D, 65; E, 80.

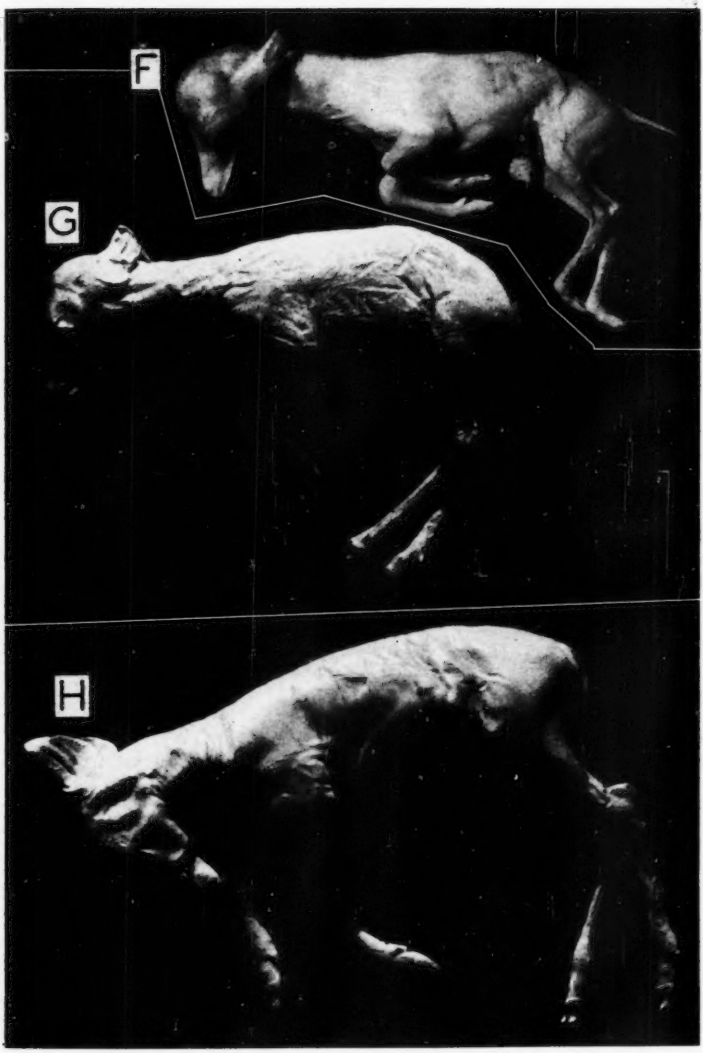

Plate 2.—Fetuses of approximate age in days: F, 89; G, 107; H, 120.

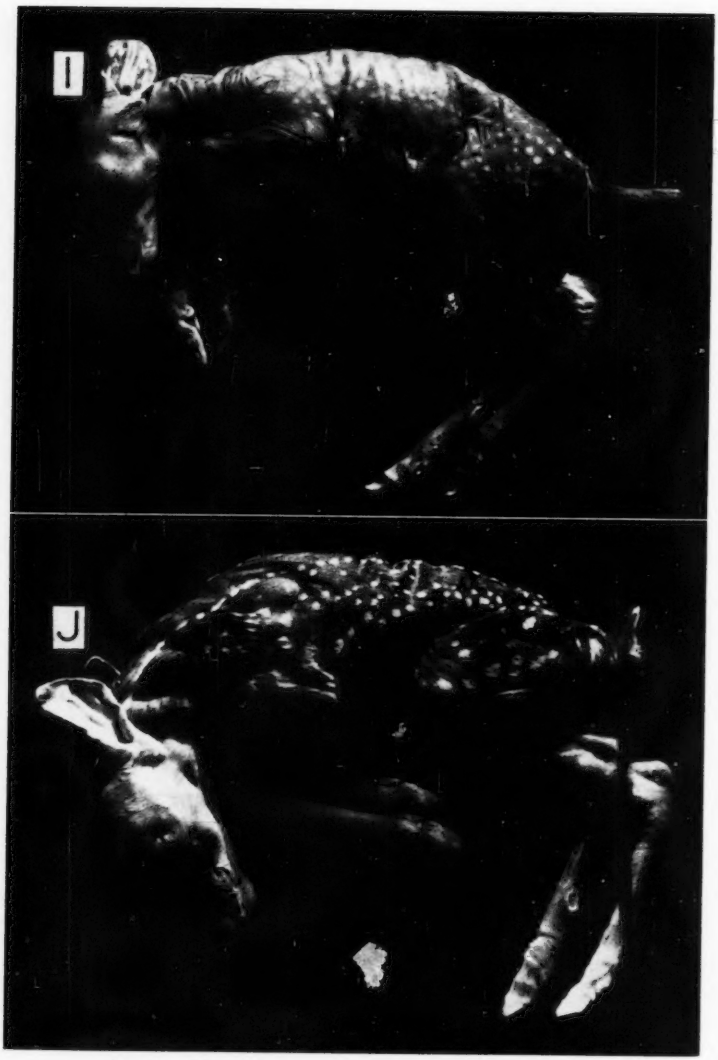

Plate 3.—Fetuses of approximate age in days: I, 144; J, 150.

A Community Study of an Oak-Hickory Association With Special Reference to Invertebrates[1]

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Introduction

This is essentially a community study of the invertebrates of an oak-hickory association situated on a floodplain of the Osage River in central Missouri. The study began in April 1946, and continued to April 1947.

The three communities studied are as follows: Lespedeza Associes (station 1), Scirpus-Echinochloa Associes (station 2), Quercus-Hicoria Association (stations 3, 4, 5 and 6).

Collections were made and physical factors were recorded at weekly intervals. Each sample from the soil stratum comprised 0.5 square foot to the depth of 3 inches and the sample from the leaf stratum comprised the dead leaves and debris which covered this area. In taking the sample from the herbs, 25 sweeps were made with an insect net provided with a 30-inch handle. The diameter of the net was 11.2 inches.

The leaves and debris were carefully raked up by hand and placed in small cloth sacks which were tied around the mouth. After the leaves had been removed, the soil was carefully placed in cloth sacks with a small garden shovel.

Samples taken from the herb stratum were placed in paper sacks. All samples were taken into the laboratory, treated with ether (except the soil) to quiet the animals and examined for invertebrates. The earthworms were preserved in 5% formalin, other specimens were preserved in 70% alcohol; the insects were mounted later.

The present study follows the principles laid down by Clements and Shelford (1939), Shelford (1913), Vestal (1913) and others. The approach is quantitative and as far as possible biotic in character.

Acknowledgements

The author wishes to acknowledge his indebtedness and to express his sincere thanks and appreciation to the following specialists in the taxonomic determination of material belonging to special groups: G. E. Gates, Oligochaeta; Harold A. Rehder, Pulmonata; H. H. Swift, Araneida; Clarence J. Goodnight, Phalangida; E. A. Chapin and E. W. Baker, Acarina; R. A. Hefner, Myriapoda; Gordon Alexander, Orthoptera; R. I. Sailer, Hemiptera; R. H. Beamer, Homoptera; C. A. Frost and Melvile H. Hatch; Coleoptera; C. W. Sabrosky, Diptera; C. F. W. Meusebeck, Braconidae and Diapridae; A. B. Gahan, Eulophidae; H. K. Townes, Ichneumonidae; Mary Talbot, Formicidae. The author is also indebted to Mr. R. E. Schappler for information on the soil, Mr. C. E. Dickinson

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for assistance in identifying the plants, and to Dr. John D. Mizelle for his many helpful suggestions throughout the manuscript. Thanks are also due Mr. Henry Balkenbusch, the owner of the land, who not only gave permission to carry on the study but offered his assistance and cooperation in every way possible.

LOCALITY AND DRAINAGE

The area studied comprises about 150 acres located 12 miles east of Jefferson City on U. S. Highway 50; it is the southwest corner formed by the intersection of the Highway with the Osage River. The particular part of the area from which all collections were taken comprises about 60 acres and 4 of the 6 stations were located in an oak-hickory association which comprises about 50 acres.

The area is a secondary one. Little could be learned about its history, but it had been disturbed by hunters and wood-cutters and at one time was used as a pasture for cattle. The disturbance by man probably has been less because a large part of the woods is occasionally inundated and remains wet for long periods and also because the only road into the area is often too wet for travel.

The average elevation is about 540 feet above sea level. The slope of the area is such that the water in the immediate vicinity south and west of the locality passes through it before reaching the Osage River. During floods most of the collecting area is inundated, especially the northern part, to the depth of about 4 feet, and sometimes it is about a week before the water begins to recede. Flooding of the area is brought about mainly by the river overflowing its western bank.

The area is drained by two natural ravines which unite near the center of the woods. From here the ditch turns east, running more or less parallel to Highway 50 for about one-fifth of a mile and empties into the Missouri about two miles away. The average size of the ravines is about 8 feet deep by 16 feet wide. Many smaller temporary streams cut through the wooded area and empty into the main ravines. Several temporary ponds are left in the wooded sections after the flood water recedes and these become dry only during protracted droughts.

The area is made up of an alluvial deposit of the present flood-plain of the Osage River. The country rock is the Jefferson City Dolomite. It is a siliceous-magnesium limestone.

The soil is of a dark color and heavy texture. It receives seepage water from adjacent upland and is well supplied with lime. The heavy texture of the soil tends to preserve the lime and is also responsible for the dark color of the soil.

An analysis of the soil from stations 2, 4, 5, and 6 gives the following data: ammonia, ranges from very low to absent; calcium, high; chloride, very low to absent; magnesium, medium to high; nitrate, from very low to absent; potassium, medium to low; phosphorus, very low; sulphate, very low to absent. The pH was neutral. The soil is the Bagnell clay loam.

METHODS AND INSTRUMENTALITY

The instrument house was located at station 5, in the center of the woods. The inside dimensions of the house were 41 x 26 inches. The front of the house was 51 inches high, the back 44 inches, giving the roof a fall of 7 inches. All sides were composed of fine-mesh wire screen.

One bulb of the dual thermograph was buried in a horizontal position 3 inches beneath packed soil and covered with leaves. The other bulb was secured horizontally by strings on two large nails which were driven into a large tree 2 feet above the ground. The thermograph was checked frequently against a thermometer which was certified by the Bureau of Standards.

The temperature as recorded by the thermograph (Fig. 1) revealed the following facts:

1. The mean annual air temperature during the day was 15.3°C.; at night, 11°C.; the mean 13.15°C.

2. There was greater variation between day and night air temperatures during the summer than during the winter. From April 1 to October 31, the mean air temperature during the day was 23°C.; during the night it was 16.8°C. From November 1 to March 31, the mean temperature during the day was 4.6°C.; at night it was 2.78°C.

3. The mean annual soil temperature was the same for night and day, being 11.1°C.

4. The soil temperature for night and day was the same from April 1 to October 31, being 15.1°C.; it was also the same for night and day from October to April 1, being 5.55°C.

5. The ground was cooler during the summer and warmer during the winter than the air above (Fig. 1).

The relative humidity was recorded by a hygrograph (recording hair hygrometer) which was occasionally checked against a cog psychrometer. The

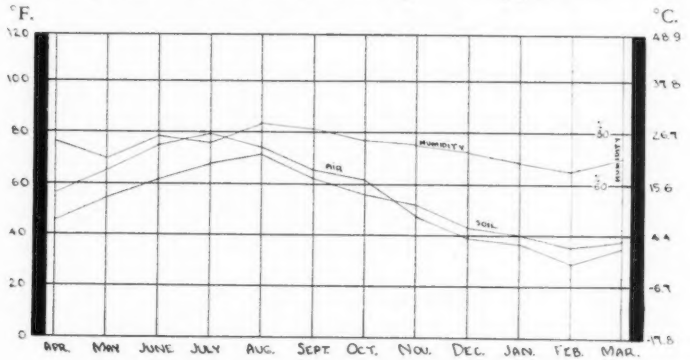

Fig. 1.—Relative humidity, air and soil temperature.

charts were changed on both instruments each week when the collections were made. These instruments did not always give satisfactory records and had to be adjusted several times.

All references to temperature and humidity were taken at station 5 by the thermograph and hygrograph respectively.

The annual relative humidity at night was 79.02%; during the day, 71.4%, the mean 75.21%. From April 1 to October 31, the humidity at night was 83.02%, during the day, 72.5%. But from November 1 to March 31, during the day the humidity was 70%; during the night 73%.

From June to November 25, Livingstone cylindrical porous cup atmometers with non-absorbing mountings were used in determining comparative evaporation rates.

At station 5 the data shows that the evaporation stress of the atmosphere increased from the herb stratum upward. At this station the average amount of evaporation per hour from June 22 to November 25, was as follows: 17 inches from the forest floor, 0.449 cc.; 6 feet from the forest floor, 0.496 cc.; 15 feet from the forest floor, 0.595 cc. At the stations where evaporation tests were made in the herb stratum for about 4 months the average amount of evaporation in cc. per hour was as follows: Station 2, 0.46; station 3, 0.427; station 4, 0.31; station 5, 0.449; station 6, 0.412.

The total rainfall (Fig. 2) for the entire period of study was 37.45 inches. Each community and its animal population will now be discussed.

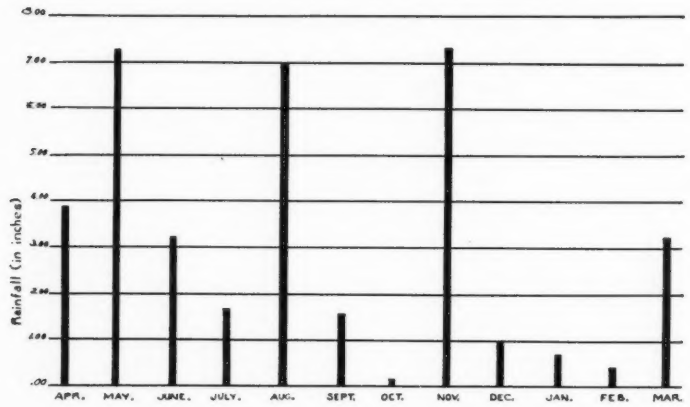

Fig. 2.—Rainfall chart.

LESPEDEZA ASSOCIES (station 1)

This community comprises about 2 acres and is located next to Highway 50 on the northwestern side of the woods. A great deal of erosion had taken place and very large ravines were cut through the northern part, running east

toward the river. The herbs were the only vegetation stratum in this associes and this was the only stratum from which samples were taken. On account of the erosion soil samples were not taken. The vegetation was practically 100 per cent *Lespedeza* and in certain places where erosion had not taken place the coverage was 100 per cent. The plants were short, on the average about 8 inches and much shorter during the winter, for this reason in wielding the net care was taken to keep it close to the ground. Care was also taken to collect samples from those spots where the vegetation was thick and the ground was not eroded. Beginning with the month of April the discussion of the animal population follows. As a rule 4 collections were made each month and any deviation therefrom is usually mentioned under the appropriate month.

April.—The invertebrate population during April increased over that of the preceding month (Fig. 3). During March the population collected totalled 170 specimens but during April it increased to 260 and of the latter number, 106 were spiders. The temperature increased from 1.82°C. for March to 13°C. for April, which was probably the cause of the increase in population.

May.—Although the temperature had increased to 17.8°C. the invertebrates collected decreased to 174 specimens. The rainfall for the month had been heavy, a little over 7 inches. This perhaps was a negative factor in the increase of the population especially since the *Lespedeza* herbs at this season of the year were less than 8 inches high. Water on the ground several inches deep for most of the month is probably a disturbing factor to invertebrates living on short vegetation. This conclusion seems correct since the population increased in all other communities during this month. The herbs were taller in all other communities.

June.—Only 3 collections were made but the specimens increased to 264. The largest number of any single group collected during this month was 56 Negro bugs. The temperature had increased from 17.8°C. in May to 23.3°C. for the present month. The rainfall was not heavy, 3.2 inches, but apparently sufficient to influence the increase of the biota since the ground still held water from the heavy rains of the past month.

July.—The population decreased from 264 in June to 148 specimens for the present month. Of the total collected, 132 were *Melanoplus femur-rubrum.* The decrease was probably due to very light rainfall during the month (1.7 inches) which was accompanied by the highest mean monthly air temperature, 26.7°C. The evaporation stress of the air was taken from July to the latter part of November and the highest amount of evaporation, 0.753 cc. per hour, was recorded for July. Light rainfall, high temperature, and a high evaporation stress of the air all favored a decrease in population.

August.—This month's collection increased over the preceding month, 172 invertebrates being taken; of this number, 74 were *Melanoplus femur-rubrum.* The temperature had dropped to 23.6°C. but the relative humidity had reached its highest mean monthly peak, 83.7 per cent. The increase in population was probably due to the decrease in temperature.

September.—During this month the specimens collected increased to 330 with the following groups influencing the total number: *Melanoplus* sp. 41, Pulmonata 26, insect larvae 38 and Cicadellidae 20. The increase in population was perhaps due to the average temperature for the month, being 18.6°C.; this temperature was not to either extreme and perhaps favorable.

October.—With the temperature continuing to fall the collection decreased to 204 specimens with the following being the most abundant: Cicadellidae 20, Aphididae 16 and *Melanoplus* sp. 54. The average temperature for the month had dropped to 16°C.

November.—There was still a further decrease in the population; the collections dropped to 134 specimens. There was no doubt at this time that the decreasing temperature was effective in reducing the invertebrate population. The mean monthly air temperature was 10°C. The most abundant groups collected were Araneida and Actididae.

December.—The mean monthly air temperature was 3.9°C., which no doubt had its influence on a further reduction in population which was represented by 72 specimens for the month, of which 70 were Araneida.

January.—The mean monthly air temperature was only a little less for the present month, being 3.3°C., but the invertebrate population had been reduced as indicated by 40 collected specimens all of which were Araneida.

February.—For the first time since September the population showed an increase; 254 specimens were collected. Of this total 130 were spiders. The mean air temperature for the month, however, was the lowest during the entire study, being 0.36°C.

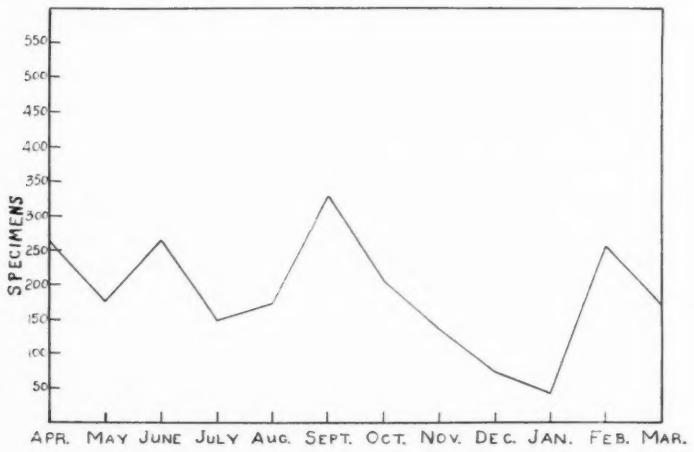

Fig. 3.—Invertebrate population of the Lespedeza Associes.

March.—The population decreased during this month; 170 invertebrates were collected, 104 were spiders. The monthly temperature had increased to 1.8°C. The relative humidity and the rainfall had also increased over the past month.

In this community 47 collections were made and a total of 2,212 specimens was collected averaging 47.06 specimens for each collection or for each 25 sweeps of vegetation.

SCIRPUS-ECHINOCHLOA ASSOCIES (station 2)

This is a small community, comprising about 3 acres and is adjacent to the *Lespedeza* community on the south. Judging from the stumps and the comparatively recent fallen logs this was once a climax oak-hickory association. The writer was informed that the trees were cut down preparatory to the placing of a saw-mill in the area but because the ground remained too wet and boggy or for other reasons the erection of the mill was never started.

The most common plants of this associes are listed in order of abundance: bulrush (*Scirpus* sp.), *Echinochloa* sp., *Muhlenbergia* sp., oak (*Quercus* sp.), hickory (*Carya* sp.), foxtail (*Setaria glauca*), and knotweed (*Polygonum* sp.). There were also a few *Ulmus* seedings, *Celtis occidentalis*, *Galium* sp. and *Isanthus* sp. The herbs in this associes were 3 feet high, extremely thick, and made sweeping difficult. Samples were taken only from the soil and herb strata. No attempt was made to compare numerically the fauna of the soil with that of the herbs. Beginning with the month of April the invertebrate population will be discussed.

April.—During this month a total of 71 specimens was taken, 27 from the soil and 44 from the herbs (Fig. 4). This was almost twice the number collected during the preceding month. The increase in temperature from 1.80°C. in March to 13°C. in April was probably the main factor influencing the increase of the population.

May.—During this month the total population collected increased to 632 individuals, only 4 from the soil and the remainder from the herbs. This very large increase was influenced by the abundance of the bug, *Cymus angustatus*, of which 586 were collected. The temperature had also increased from 13°C. for the month of April to 17.8°C. for May, which no doubt was a factor influencing the increase of the insect fauna.

June.—During this month the specimens collected dropped to 367; of this number 13 were taken from the soil and the remainder from the herbs. The increase in temperature to 23.3°C. was apparently unfavorable to a population increase. The bug, *Cymus angustatus*, was reduced in the collections and probably influenced the reduction of the total number of specimens. Only 21 *Cymus angustatus* were taken.

July.—With the air temperature reaching its highest mean monthly peak, 26.7°C., and the rainfall being light, 1.7 inches, the total population collected was reduced to 110 specimens; 16 were taken from the soil and the remainder

from the herbs. The high temperature and light rainfall influenced the population decrease.

August.—The herb stratum yielded 156 and the soil 4 specimens. The mean air temperature for the month had dropped to 23.6°C. but the rainfall was 7 inches. The decrease in temperature was the main apparent factor in the population increase.

September.—The total specimens collected increased to 751 with 129 being taken from the soil and the remainder from the herb stratum. The total population was influenced by the collection of 125 Formicidae, 82 *Lygus oblineatus*, 140 Diptera and 40 Cicadellidae. The temperature and rainfall both had been reduced. The mean monthly air temperature was 18.6°C. which was probably a favorable factor.

October.—The population was greatly reduced; 144 specimens were collected from the herbs and 10 from the soil. Both the temperature and relative humidity had dropped since the past month.

November.—Although the temperature had decreased from 16°C. in October to 10°C. for the present month the invertebrate fauna collected had increased from 154 in October to 223 specimens in November. The groups most abundant during the month were 26 Cicadellidae, 46 *Lygus* sp. and 24 lepidopterous larvae.

December.—The temperature dropped to 3.9° C. and the specimens collected decreased to 84; 44 were taken from the soil and the remainder from the herbs.

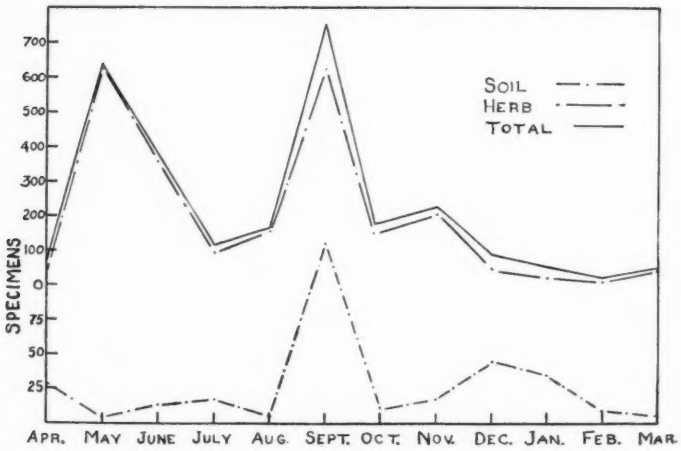

Fig. 4.—Invertebrate population of the Scirpus-Echinochloa Associes.

January.—Only 54 specimens were taken from the soil and 20 from the herbs. The low temperature was having a marked effect in reducing the population.

February.—During this month only 17 specimens were collected, and 9 of these were taken from the soil stratum. It should be mentioned that February showed the lowest mean monthly temperature, 0.36°C., and the smallest total number of specimens collected for any month. The lowest number for any month was also taken by sweeps from the herbs.

March.—During this month the temperature increased to 1.8° C. and the total population collected increased to 45 specimens.

In this community 48 collections were made. From the soil stratum 312 specimens were taken averaging 6.5 specimens for each 0.5 square foot. From the herbs 2,356 specimens were collected averaging 49.08 specimens for each 25 sweeps.

QUERCUS-HICORIA ASSOCIATION (station 5)

Collections were made from 4 stations in this association but since there was no fundamental difference between the populations, only station 5, will be discussed. However, use will be made of materials collected at all stations in this community under certain discussions at noted later. The present stations were selected mainly on the basis of differences in terrain. All factors considered, station 5 seemed to be the best from which to obtain samples which would represent the community as a whole. At this station there had been less disturbance, the dead leaf stratum was thicker, the vegetation was more profuse and varied and the terrain had a somewhat higher elevation at this point than any other place in the community.

In this association there were several species of *Quercus:* chestnut oak (*Q. prinus*), black oak (*Q. velutina*), bur oak (*Q. macrocarpa*) and northern red oak (*Q. borealis*). The *Hicoria* were pignut hickory (*H. ovalis*) and shagbark hickory (*H. ovata*). Many of the oaks and hickories were from 65 to 75 feet high and from 12 to 18 inches in diameter. There were also a few of the following scattered through the community: false buckthorn (*Bumelia lanuginosa*), southern buckthorn (*B. lycioides*), white mulberry (*Morus alba*), red mulberry (*M. rubra*), dogwood (*Cornus* sp.), white ash (*Fraxinus americana*), and hackberry (*Celtis occidentalis*). In the herb stratum the following plants are listed in order of abundance: bulrush (*Scirpus* sp.), starwort (*Aster pilosus*), wood reed grass (*Cinna arundinacea*), blackberry (*Rubus alleghenicnsis*), and ground cherry (*Physalis* sp.), *Penisperm canadensis,* trumpet creeper (*Tacoma radicans*) and many seedlings of *Hicoria* sp., *Ulmus* sp., *Fraxinus* sp., *Quercus* sp., and *Platanus* sp. The collecting at this station was limited to an area of about 2 acres. Three strata were studied, soil, dead-leaves and herbs. The herbs were about 2 feet high and the coverage was about 100 per cent. The leaf stratum averaged about one inch in depth. The invertebrate population will now be discussed.

April.—The temperature increased from 1.82°C. in March to 13°C. in

April, but the invertebrate population decreased slightly. A total of 57 specimens were collected for the month, 6 from the soil, 21 from the leaf stratum and the remainder from the herbs (Fig. 5).

May.—With an increase in temperature up to 17.8°C. the invertebrate collection increased to 246 organisms. Four of these were taken from the soil, 4 from the leaves and the remainder from the herbs.

June.—The temperature increased to 23.3°C. and the collections decreased to 237 specimens with 9 being collected from soil, 78 from the leaf stratum and the remainder from the herbs. The temperature had probably gone too high to serve as a favorable factor for an increase in population. On the 21, 70 ants were taken from the leaf stratum.

July.—During this month the mean monthly temperature reached its highest peak, 26.7°C. With only a light rainfall the population collected was reduced to 138 organisms, 8 from the soil, 2 from the leaf stratum and the remainder from the herbs. A high temperature and light rainfall were unfavorable to a population increase.

August.—With a reduction in temperature to 23.3°C. and a heavy rainfall, 7 inches, the specimens collected increased to 297 organisms. The soil stratum yielded 14, and the leaf stratum 9 of this total number; the remainder was collected from the herbs. Sixty-two Cicadellidae, 20 Araneida and 18 *Euschistus euschistoides* were collected in the herb stratum.

September.—During this month the mean temperature was 18.6°C. and the population collected increased to 438 specimens, 26 from the soil, 18 from leaves and the remainder from the herbs. Temperature was the most favorable factor in the population increase. The most abundant groups collected were 58 Araneida, 22 *Jalysus spinosus*, 32 Aphididae and 20 Formicidae; all were collected in the herb stratum except the ants which were taken in the leaf stratum.

October.—With a mean monthly temperature of 16°C. the specimens collected increased to 797, 12 from the soil, 13 from the leaves and the remainder from the herbs. The groups influencing the total population most were Araneida, 154; *Lygus oblineatus*, 112; Cicadellidae, 66; plant lice, 56 and flies, 28.

November.—The mean monthly temperature decreased to 10°C. but the population decreased but slightly; the collected specimens were 764, 18 from the soil, 66 from the leaf stratum and the remainder from the herbs. In spite of the low temperature most of the fauna (680 specimens) were collected from the herb stratum. The largest groups collected affecting the total population were *Lygus oblineatus* 224, and Araneida 202; these groups were taken in the herb stratum.

December.—The mean monthly temperature was 3.8°C. and the total population for the month was 112, soil and leaf 21 each and the remainder

from the herbs. The low temperature apparently had very definite influence in reducing the total population.

January.—The mean monthly temperature had decreased just slightly; it was 3.3°C., but the total population collected increased to 142 specimens; of this total number 14 were collected from the soil, 66 from the leaves and the remainder from the herbs. Temperature was the main factor influencing the reduction in population.

February.—The mean monthly temperature reached its lowest minimum, 0.36°C., and the population collected for the month also reached the lowest monthly total, being only 49 specimens. Of this total number, 19 were colletced from the soil, 20 from the leaves and the remainder from the herbs.

March.—The mean monthly temperature increased to 1.80°C.; and the population collected also increased, it was 61 specimens for the month. Eight were collected from the soil, 13 from the leaf layer and 40 from the herbs.

Forty-seven collections were made. From the soil stratum 159 specimens were taken averaging 3.38 specimens for each collection. From the leaf stratum 331 were collected averaging 7.04 for each collection and from the herbs 2,848 were collected averaging 60.59 for each collection.

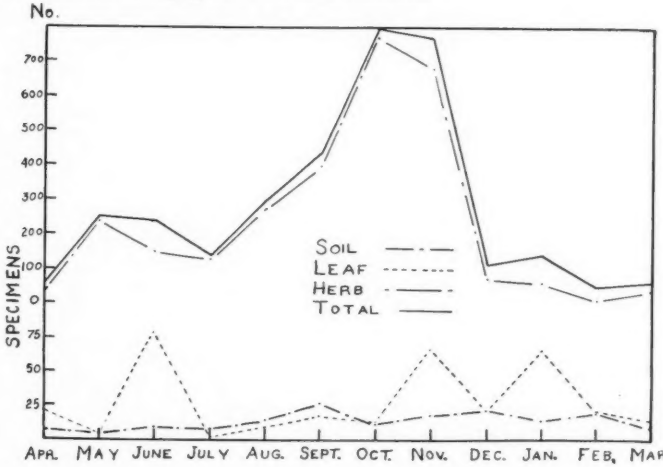

Fig. 5.—Invertebrate population of the Quercus-Hicoria association.

SUMMARY OF ANIMAL POPULATION

April.—The population at all 6 stations increased except that of two located in the Quercus-Hicoria Association, which showed a slight decrease. The stimulus responsible for the increase was apparently an increase in temperature.

May.—All stations increased in population except the one in the *Lespedeza* Associes. Increased temperature apparently was the main stimulus responsible for the increase in population.

June.—All stations decreased in animal population except the one located in the *Lespedeza* Associes. High temperatures and only moderate rainfall possibly were unfavorable factors.

July.—All 6 stations decreased in population. A high temperature accompanied by a light rainfall apparently were unfavorable factors.

August.—All stations increased in population. Reduction in temperature and increased rainfall might have been the favorable factors.

September.—All stations increased in population. Temperature was the most apparent favorable factor, not to either extreme, 18.6°C.

October.—All stations decreased except two which were located well inside the woods. Apparently the falling temperature was beginning to have its effect in reducing the population.

November.—Only one station increased in population, all others decreased. Reduction in temperature apparently was the main factor in reducing the population.

December.—All stations decreased in population. The low temperature was now having a great effect in reducing the population.

January.—All stations decreased except two located well inside the woods. These two increased in population.

February.—Three stations increased in population and 3 decreased.

March.—As the temperature increased for the month the population also increased. All stations increased in population except one.

Temperature seems to be a very important physical factor in controlling invertebrate population; this is especially true during the winter. Temperature and moisture taken together seem to be more important in this respect during the summer than during the winter.

In general those stations located within the interior of the woods showed more frequent increases in population during fall and winter than those toward the periphery. This might indicate that insects migrate to the interior of woods to hibernate. The following section deals with the species collected in the area studied.

THE INVERTEBRATES

In the following discussion since the number of animals of a given species or group refers to the total number for the entire period of study and for the whole area (all stations combined) it might be necessary to state the total number of collections in each stratum for the entire period of study. This is in keeping with the quantitative viewpoint. From the soil a total of 236 collection were made, 139 from the leaf stratum and 283 from the herbs.

OLIGOCHAETA

This order is represented by 3 species and 146 individuals. Only one specimen of *Lumbricus terrestris* Linn. was taken (Table 1).

Allolobophora caliginosa (Savigny) (Lumbricidae).—This was by far the most abundant species, 120 were collected. These worms were taken in every month except June and July; the largest numbers being taken in November, March, December and January. Both juveniles and adults were included. They were fairly evenly distributed through all communities from which soil samples were taken.

The reaction of earthworms is limited to the soil and leaf strata but more to the former. Darwin (1882) in his classic work on earthworms, *The Formation of Vegetable Mould Through the Action of Worms,* stated that it may be doubted whether there are many other animals which have played so important a part in the history of the world as these lowly organized creatures. Worms enrich the soil and increase its fertility by bringing to the surface soil from beneath minging with it half-decayed leaves and other organic matter. In this study the number of worms taken in this floodplain area would seem to exert a greater reaction as well as coaction in the soil than any other group. The soil being moist most of the time makes for easy mobility and with a leaf layer about an inch or more in thickness feeding of the worms is facilitated.

PULMONATA

Seven species and 133 specimens were collected; 124 of these were collected in the herb stratum. Snails were usually found feeding on the herbs during rainy weather. Snails are herbivorous and considered as pests.

ARANEIDA

This order was comparatively abundant, 2,538 individuals and 39 species were taken. Most of the spiders were immature. They were much more abundant at the stations located in the woods than at the field stations. By far the greater number of species and individuals were taken from the herb stratum. The web-builders comprised 23 species and the non web-builders 16.

Spiders are predaceous and cannabalistic. They are considered exceeding beneficial because of the insects they devour, and many such insects are serious pests to plants and animals. Lowrie (1942) concluded that spiders show a negative reaction to heat. The discussion of the species which follow confirmed this conclusion.

Dictyna volucripes Keys (Dictynidae).—A total of 610 were taken; all were collected in the herb stratum and all were immature. Some were taken in each month except May, August and September. This spider is the number one predominant in the Lespedeza Associes. From this associes 548 were collected. In the Scirpus-Echinochloa Associes about 45 yards away only 8 were taken. The population peak was reached in February when 157 were collected. It should be recalled that the temperature reached its lowest monthly

average in February, being 0.36°C. This spider was taken in larger numbers during the cool and cold months than during the warm or hot seasons. The number taken each month follows: April, 110; June, 10; October, 66; November, 18; December, 52; January, 51; February, 157; and March, 146.

Frontinella communis (Hentz) (Linyphyiidae).—This species was taken mainly during the cool and cold months. The following data show the number taken each month: April, 16; July, 6; September, 10; October, 23; November, 49; December, 41; January, 46; February, 33; and March, 10. Both juveniles and adults were collected. All specimens were taken in the herb stratum and mostly from the stations located in the woods.

Linyphia marginata C. Koch (Linyphiidae).—A total of 146 was collected; all were immature, and all were taken in the herb stratum. The largest numbers were taken during the cool and cold months. This species was limited in the collection to the stations located in the woods. This species also appears to be able to withstand very low temperatures.

Leucauge venusta (Walck.) (Argiopidae).—A total of 160 was collected. The largest numbers were taken during December, February, January, November and October. None were collected during the estival period. The two stations where the largest numbers were taken were located in the climax community. All were immature, and all were taken in the herb stratum.

Mangora placida (Hentz) (Argiopidae).—A total of 408 specimens was collected; all were immature. Some were taken every month of the year except August. Very few were collected during the hottest part of the summer. Since all specimens were taken in the herb stratum and many were taken during some of the coldest months, it appears that this species is quite able to withstand freezing and even subfreezing temperatures. They were collected in much larger numbers at the stations located in the climax forest community.

Tetragnatha sp. (Argiopidae).—A total of 160 specimens was collected; all were immature, and all were taken in the herb stratum. The largest monthly collections were made in January and December with 59 and 29 collected in each month respectively. This is a predominant in the Lespedeza Associes.

Pisaurina mira (Walck.) (Pisauridae).—This species was collected every month, except the two coldest, January and February. All were taken in the herb stratum, a total of 320. The population peak was reached in September when 90 were collected; the next highest month in population was October with 80. All spiders were collected at stations located within the woods.

ACARINA

Only 3 species were collected as the following description will show.

Allothrombium missouriense Ewing (Thrombidiidae).—This species was collected in all 3 strata, a total of 44, but mainly in the herb and leaf strata.

Thrombidium locustarum Riley (Thrombidiidae).—All 26 specimens except one was taken in the soil.

Dermacentor variabilis Say (Ixodidae).—Only one specimen was collected, the date was January 12. This tick has recently become of great importance, since it is now known to transmit Rocky Mountain spotted fever and tularaemia, two important diseases of man (Matheson, 1947).

PHALANGIDA

Only 6 specimens of one species were collected. The species was *Leiobunum crassipalpe* Banks.

DIPLOPODA

Seven species of the order were taken and none were represented by more than one individual. They were collected largely in the soil stratum, but a few were taken from the leaf stratum.

CHILOPODA

Four species and 37 specimens were collected. Six specimens were collected in the leaf stratum and the remainder from the soil. The most commonly occurring species was *Arenophilus bipuncticeps,* 20 were found in the soil and 2 in the leaf stratum. Chilopods are predaceous and as such are considered beneficial since they devour injurious insects.

ORTHOPTERA

Fifteen species and 2,565 specimens were collected. All except 3 specimens were taken in the herb stratum.

Practically all insects of this order were taken between July 6 and November 1. In fact only one species was taken after the latter date—*Tettigidae lateralis* was taken on January 12. This was also the first species of Orthoptera to be taken after the beginning of the warm season.

Melanoplus femur-rubrum (DeGeer) (Acrididae).—The first of these insects were collected in the Lespedeza Associes on July 6, when 22 were taken and the last were collected on November 10 in th same community when 4 were taken. This insect was a predominant in the Lespedeza Associes, feeding on the *Lespedeza.* The total number taken each month is as follows: July, 122; August, 98; September, 48; October, 74; and November, 8. Thus it is seen that the largest number was taken during July, the hottest and driest of the summer months. Both adults and juveniles were collected; all were taken in the herb stratum. This grasshopper is a very destructive species destroying native grasses and nearly all cultivated crops.

HEMIPTERA

This order included 44 species of which 39 were taken in the herb stratum. Of 2,565 specimens taken all but 30 were taken in the herb stratum.

Many Hemiptera are plant feeders, others attack animals, including man. Some are beneficial and some injurious.

Lygus oblineatus Say (Miridae).—This was a very common bug; 1,068 were collected. Some were taken in every month of the year but mostly during

October and November; during October, 232 were taken and during November, 490. They were found in the communities studies as follows: Lespedeza Associes 18, Scirpus-Echinochloa Associes 86, and at the 4 stations in the Quercus-Hicoria Association 964 were taken. All specimens were taken in the herb stratum and all were adults.

Cymus angustatus Stal. (Lygaeidae).—The total number collected was 948. During May 868 were collected; some were also collected in June, July, August and October. Only adults were taken, all in the herb stratum. In the Scirpus-Echinochloa Associes 598 were collected. Some were taken in all communities studied.

Oedancala dorsalis (Say) (Lygaeidae).—This insect was collected during May, June, and July only, a total of 198. All specimens were adults and all were taken in the herb stratum. Some were taken in all communities except the Lespedeza Associes.

Jalysus spinosus (Say) (Neididae).—A total of 87 was collected, all were adults and all were taken in the herb stratum. The first ones were taken on July 14, and the last on December 21.

Corimelaena pulicaria (Germar) (Cydnidae).—A total of 68 were taken; the first were collected on May 10, and the last on February 15. Between these dates some were collected every month except October and November.

HOMOPTERA

This is a diverse group of insects. All are plant feeders, the order being one of the most injurious to plant life (Essig, 1934). The order differs greatly in habits as well as economic relationships.

Thirty-eight species and 888 individuals were collected. All specimens except 18 were taken in the herb stratum and all species except 2 were also taken in the same stratum.

Lepyronia Quandrangularis (Say) (Cercopidae).—A total of 258 individuals were collected, 248 from the herb stratum and the remainder from the soil. Some were taken in every month except May, February and March. The first ones were collected on April 5, and the last on January 2, when 2 were collected on each date. During the month of July, 54 were collected. However, the monthly peak in population was not reached until August and September when 76 were taken in each month. During October the number dropped to 14, but for November, it increased to 28. Only 4 were taken in December and 2 in January. Both adults and immature forms were taken in the collections. They were distributed in the communities as follows: Scirpus-Echinochloa 84, and from the 4 stations in the Quercus-Hicoria Association, 174.

Draeculacephala mollipes Say (Cicadellidae).—A total of 183 was collected, three from the soil and the remainder from the herbs. The first was collected on July 6, and the last on November 4. The population peak was

reached during September when 76 were collected. Only adults were taken. They were taken in all communities except the Lespdeza Associes.

Paraphelpsius irroratus (Say) (Cicadellidae).—This insect was collected during July, August, and September only, but mostly during July. Only adults were taken. All were collected in the herb stratum. A total of 88 was taken.

Macrosiphum eupatori (Williams) (Aphididae).—A total of 159 specimens was collected, all in the herb stratum. The first ones were taken on May 10, and the last on October 26.

COLEOPTERA

Coleoptera are adapted for living under the greatest varieties of conditions, being aquatic and terrestrial, aerial and subterranean, carnivorous and herbivorous, beneficial and destructive. The great majority are vegetarians and hence many species are serious pests.

This order was small in specimens but large in species. Only 342 specimens were collected as against 84 species. Fifty species were collected in the herb stratum, 13 in the leaves and 30 from the soil. The specimens were distributed as follows: 37 from the soil, 11 from the leaves and 294 from the herb stratum.

DIPTERA

With the exception of those which pollinate plants and destroy noxious insects and plants, the order is chiefly injurious and by far the most serious to human health and welfare (Essig, 1934). Only 8 species were determined. About 432 adults were collected.

Mosquitoes were very numerous and annoying. The locality being low and containing a number of temporary ponds afforded exceedingly favorable breeding places for the mosquitoes. The most common species were *Aedes trivittatus*, *A. triseriatus* and *Anopheles punctipennis*.

HYMENOPTERA

The great number of parasitic and predatory species among the Hymenoptera is important, for they serve as checks to the excessive reproduction of many insects (Matheson, 1947). This is by far the most important beneficial order of insects, in spite of the losses incurred by the sawflies, horntails and ants (Essig, 1934).

Twelve species and 667 specimens were collected. Half of the species were ants and more than half of the individuals were also ants. Ten species were collected in the herb stratum, and the specimens were distributed as follows: soil 415, leaf stratum 181 and herb 71.

Braconidae, Ichneumonidae and Eulopidae, taken in this study, are known to be parasitic in the larval stage upon a number of insects.

Clements and Shelford (1939) said of ants: Perhaps no other small animal exerts such a variety of influence as these small insects though unfortunately there have been few or no quantitative studies of the effect of this group.

Ants, no doubt on account of their large numbers, their highly developed social organization, their intense activity and feeding habits, exert a very great influence upon the biotic community in which they live. They are, therefore, coactors in no small capacity and have important reactions on the soil. They seem to be all the more important since they are usually found not only in the soil but also in the leaf, herb and tree strata in appreciable numbers.

PERIODS OF ASPECTION

Because of physical and biological differences among the several communities studied, it was difficult to draw the line of demarcation between the various seasonal changes for the community as a whole, therefore, the periods of aspection as designated can hardly be any too accurate and should be taken as an approximation. The year covered by this work was divided into 6 biotic seasons as characterized below (Weese, 1924).

Prevernal period (March 15 to April 19).—The entire season was quite wet and characterized by rising temperature. About April 1, many plants were beginning to leaf and the invertebrate population was definitely on the increase.

Vernal period (April 20 to June 14).—There was an abundance of rain. The air temperature was rapidly rising; and the humidity had also increased. About May 6, many mosquitoes, dragonflies and grasshoppers were seen on the wing. The population had increased markedly over the preceding period.

Estival period (June 15 to September 15).—At the beginning of this period the air temperature had reached the upper twenties. The first evaporation test was recorded on June 29, and was 0.4 cc. per hour but it soon increased from 2 to 3 times this amount but was again reduced the latter part of the period. Between August 10 and 25, very heavy rains occurred which inundated the greater part of the area, but by September 15, the ground was quite dry. The humidity increased over that of the preceding period. The population had decreased.

Serotinal period (September 16 to October 12).—During this period the humidity was about the same but the temperature had decreased. The rainfall was scant. There was a great increase in population, and the largest average number was collected of any period.

Autumnal period (October 13 to December 7).—The temperature, the evaporation and the humidity had been reduced. The population had also been reduced.

Hiemal period (December 8 to March 14).—This was the period of lowest temperature and the hibernation of many forms. The humidity had decreased; and the population reached its lowest minimum during this period.

INVERTEBRATES EXPOSED TO LOW TEMPERATURE

During fall and early winter the gradual reduction of temperature and scarcity of food are accompanied or followed by a degree of lessened activity

and lowered metabolism of the biotic community. This leads to a period of hibernation by many invertebrates.

Dowdy (1947) noted that the reduction of invertebrates in the vegetation started about October 4, at an air temperature of about 12.8°C. and that invertebrates commenced increasing on vegetation again about May 5, at approximately the same temperature. However, he noted that a very marked reduction of invertebrates in the vegetation did not occur until about December at a temperature of about 1.67°C. Holmquist (1926) found that the hibernation period for arthropods in the Chicago region extended from the middle of November to the latter part of March. Brown (1931) noted near St. Charles, Mo., that invertebrates begin hibernating about November 1, and they emerge about April 15. Cameron (1913) maintained that "temperatures below 4.44°C. in the soil have a decided effect on insect life, which assumes a lethargic condition, accompanied by a cessation of all vital activities." Studying the influence of temperature on vertical migration of invertebrates inhabiting different soil types Dowdy (1944) concluded that the most effective temperature influencing the downward movements of invertebrates in the fall is between 3.33°C. and 7.22°C., usually about 5.56°C. It has been shown by numerous workers that the beginning of hibernation in cold-blooded animals is often marked by a reduction of the water content of the organism, and it is equally true that the breaking-up of hibernation in these forms is usually marked by a taking in of water" (Townsend, 1926). Weese (1924) has shown that young spiders emerge from the winter cocoons only under conditions of high humidity of the surrounding air.

It seems that hibernation is influenced mainly by 3 factors—temperature, food and moisture. However, these may not be the only factors influencing hibernation. Folsom (1922) stated that the codling-moth larva begins hibernation before the temperature falls and before food fails; and mosquitoes begin to hibernate before cold weather sets in.

In this study which is based on a general continuous reduction in the number of invertebrates during the autumnal period and upon their general increase during the prevernal period, hibernation started about November 25, and was broken-up about April 19. The air temperature on November 25, was 0.56°C. The humidity on November 25, was 68 per cent and the average for the preceding week was also 68 per cent. On April 19, the air temperature was 20°C. and the average for the preceding week was 12.8°C. The humidity on April 19, was 93 per cent and the average for the preceding week was 73 per cent.

From December through March it appears that hibernation was in full force. Therefore, it might be in order to give the average of certain physical data during these 4 months: December-temperature 4.44°C., humidity 73.4 per cent; January-temperature 3.35°C., humidity 71 per cent; February-temperature 0.36°C., humidity 66.4 per cent; March-temperature 1.94°C., humidity 71 per cent. During the month of December 366 invertebrates were collected from herb stratum with the insect net; 67 of these were various species of spiders. During January 312 were collected from the herb stratum and 105 were spiders. During February 440 were taken from the herbs, 84 being spiders. During March 498 were collected and 129 were spiders.

During the 4 months of low temperature all collecting days were not warm; for instance, on February 11, the air temperature was 0.56°C. and the average for the preceding week was 1.11°C. On this date 92 specimens were collected from the herb stratum. On February 22, the air temperature was 2.22°C. and the average for the preceding week was 0.56° C. On this date 76 specimens were collected from the herb stratum. On March 3, the air temperature was 1.67°C. and the average for the preceding week was also 1.67°C. On this date 54 invertebrates were collected from the herbs.

During the winter partly on account of hibernation, interaction in the biotic community is at a low ebb. Interaction in the community has been the driving force behind the origin and development of the concept biotic community in the study of ecology. During the summer animals depend more upon plants for protection, and upon plants and animals as food than during the winter, and hence interaction is more pronounced.

GENERAL SUMMARY AND CONCLUSIONS

This study comprised the invertebrates of an oak-hickory association in a floodplain locality. It was started April 1946 and continued to April 1947. The area is a secondary one. Collections were made and physical factors recorded at approximately weekly intervals. Collections were made from the herb stratum by taking 25 sweeps with the insect net. From the soil 0.5 square foot was taken to the depth of 3 inches; the dead leaves which covered this area comprised the samples from the leaf stratum.

The soil is the Bagnal clay loam. The pH as neutral. The mean annual air temperature was 13.15°C. The mean annual relative humidity was 75.21%. The total rainfall was 37.45 inches. The evaporation stress of the atmosphere increased from the herb stratum upward.

From the Lespedeza Associes collections were made from the herbs only and the average number of specimens for each 25 sweeps of vegtation was 47.06. Fifty-three species were taken. Forty-seven collections were made.

In the Scirpus-Echinochloa Associes 48 collections were made and the average number of specimens taken from 0.5 square foot of soil to a depth of 3 inches was 6.5, and from the herb stratum the average was 49.08. From the soil 17 species were collected and from the herbs 65.

In the Quercus-Hicoria Association 4 collecting stations were established with the following results being obtained:

At station 3, 49 collections were made and the average number taken in the soil samples was 12.38, and from the herbs 44.69. From the soil 31 species were taken and from the herbs 68. At station 4, 48 collections were made and the average number from the soil was 4.83, from the leaf stratum 3.43 and from the herbs 45.16. The number of species taken from each stratum were: soil 13, leaf 19 and herb 54. At station 5, 47 collections were made and the average number collected from the soil was 3.38, from the leaf stratum 7.04 and from the herbs 60.59. The number of species collected from each stratum was as follows: soil 22, leaf 15 and herb 81. At station 6, 44 collections were made and the average number collected in the soil was 3.22, from the leaves

3.36 and from the herbs 48.52. The number of species were soil 10, leaf 7 and herb 76.

The 4 stations in the Quercus-Hicoria Association would therefore have the following average for each stratum: herb—65 species and 49.74 specimens; leaf—19 species and 59.5 specimens; soil—13.6 species and 4.61 specimens.

Temperature alone is a very important factor in controlling invertebrate population; this is especially true during winter. Temperature and moisture taken together seem to be more important in this respect during the summer than during the winter.

Many species remain on the herbs during the winter and are able to withstand freezing and subfreezing temperatures for long periods of time. This is especially true of many species of spiders.

The hibernation period extended from about November 25 to about April 19.

The largest average number of specimens and species was taken during the serotinal period and the smallest number during the hiemal period. The autumnal period exceeded the estival in specimens but was less in species. The vernal period exceeded the prevernal in number of specimens but had a smaller average number of species.

The most abundant groups were, in order of population: Hemiptera, Orthoptera, Araneida, Homoptera (mostly leafhoppers), and Hymenoptera (mostly ants). The groups standing high in species were, in order of abundance: Coleoptera, Hemiptera, Araneida and Homotpera.

The most abundant species, in order named, were *Lygus oblineatus, Cymus angustatus, Dictyna volucripes, Mongora placida, Melanoplus femur-rubrum, Pisaurina mira, Lepyronia quadangularis* and *Draeculacephala moilipes.*

A net total of 264 species were identified from the area investigated.

TABLE 1.—The list of species identified from the area studied. The date or dates on which each species was collected are given. im=immature; ad=adult.

Annelida
  Oligochaeta
    Allolobophora caliginosa (Savigny)—im, ad, Apr. 5, 12, 19, 26; May 10, 31; Aug. 25, 31; Sept. 5, 15, 22; Oct. 6, 12, 19; Nov. 4, 10, 16, 25, 30; Dec. 7, 14, 21, 27; Jan. 12; Feb. 1, 11, 15; Mar. 3, 22, 29.
    Lumbricus terrestris Linn.—ad, Mar. 22.
    Octolasium lacteum (Orley)—im, ad, Apr. 5, 19; May 10, 25; Nov. 16, 25; Dec. 14, 27; Feb. 22; Mar. 22, 29.
Mollusca, Gastropoda
  Pulmonata, Pupillidae
    Gastrocopta pentodon (Say)—ad, Sept. 15, 22, 28.
    Vertigo milium (Gould)—ad, Sept. 15, 22, 28.
    Vertigo ovata (Say)—ad, Sept. 15.
  Succinea
    Succinea grosvenorii Lea—im, Aug. 10, 31; Sept. 15, 28.
    Succinea avara Say—im, ad, May 31; June 7, 14.
  Zonitidae
    Retinella indentata (Say)—ad, July 20; Aug. 31.
    Retinella indentata paucilirata (Morelet)—ad, Oct. 6; Dec. 21, 27.
Arthropoda, Arachnida
  Araneida, Uloboridae

Uloborus glomosus (Walck.)—im—Apr. 12; Nov. 10; Dec. 7; Feb. 22; Mar. 15, 29.

Dictynidae

Dictyna volucripes Keys—im, Apr. 5, 12, 19, 26; June 14; Oct. 6, 12, 19, 26; Nov. 4, 16, 25, 28, 30; Dec. 7, 14, 27; Jan. 12, 26; Feb. 1, 11, 15, 22; Mar. 15, 22, 29.

Dictyna sublata (Hentz)—im, Apr. 19; May 10, 31.

Dictyna sp.—im, Apr. 5, 19; Aug. 10; Oct. 6, 19; Sept. 15, 22.

Theridiidae

Crustulina altera G. and A.—ad, Dec. 14.

Euryopis funebris (Hentz)—im, Mar. 29.

Micryphantidae

Ceraticelus fissiceps (Camb.)—im, ad, Sept. 5, 15, 22, 28; Oct. 6; Nov. 10.

Ceratinopsis purpurescens Keys—ad, May 10.

Eridantes erigonoides (Emerton)—ad, Oct. 19.

Sisicottus longisetosus (Emerton)—ad, Dec. 7.

Linyphiidae

Frontinella communis (Hentz)—im, ad, Apr. 5, 12, 19, 26; July 27; Sept. 15, 28; Oct. 6, 19, 26; Nov. 4, 10, 16, 25, 30; Dec. 7, 14, 27; Jan. 12, 27; Feb. 1, 11, 22; Mar. 15, 22, 29.

Linyphia marginata C. L. Koch—im, Apr. 5, 19; Aug. 3; Oct. 6, 12, 19; Nov. 10, 25, 30; Dec. 7, 14, 21; Jan. 12, 26; Feb. 11, 15; Mar. 22, 29.

Argiopidae

Acacesia foliata (Hentz)—ad, July 20; Aug. 3.

Araniella displicata (Hentz)—im, Sept. 22.

Argiope aurantia Lucas—ad, Sept. 5.

Argiope trifasciata (Fors.)—ad, Oct. 12.

Aranea sp.—im, Sept. 5.

Eustala sp.—im, Aug. 10; Sept. 22; Oct. 19; Dec. 14; Jan. 12.

Larinia directa (Hentz)—im, Oct. 26.

Leucauge venusta (Walck.)—im, May 31; Oct. 12, 16, 19; Nov. 4, 10, 16, 30; Dec. 7, 14; Jan. 12, 26; Feb. 11, 15, 22; Mar. 15, 22, 29.

Mangora placida (Hentz)—im, Apr. 5, 19, 26; May 10; June 21; July 20; Sept. 15, 22, 28; Nov. 6, 12, 16, 25, 30; Dec. 7, 14, 27; Jan. 12, 26; Feb. 1, 11, 15, 22; Mar. 15, 22, 29.

Mangora gibberosa (Hentz)—im, Aug. 3.

Marxia stellata (Walck.)—im, Apr. 19, 26; May 10.

Singa sp.—im, Apr. 12; Jan. 12; Mar. 22, 29.

Tetragnatha sp.—im, Apr. 5, 12, 19, 26; Sept. 28; Oct. 12, 19; Nov. 16, 25, 30; Dec. 7, 14, 27; Jan. 12, 26; Feb. 1, 11; Mar. 3, 22, 29.

Wixia ectypa (Walck.)—im, Oct. 6; Nov. 10; Jan. 12, 26; Feb. 11, 15; Mar. 29.

Agelenidae

Agelenopsis pennsylvanica (C. L. Koch)—ad, Sept. 28.

Cicurina sp.—im, Aug. 3, 10.

Oxyopidae

Oxyopes salticus Hentz—im, Aug. 31; Oct. 6, 19; Sept. 28; Dec. 14.

Hahniidae

Hahnia sp.—ad, Dec. 7.

Pisauridae

Dolomedes sp.—im, Sept. 15; Nov. 10.

Pisaurina mira (Walck.)—im, Apr. 5, 12 19, 26; May 10, 31; June 7, 14, 21; July 14, 20, 27; Aug. 3, 10, 25, 31; Sept. 5, 15, 22, 28; Oct. 6, 12, 19, 26; Nov. 10, 16, 25, 30; Dec. 7, 14; Mar. 22.

Lycosidae

Lycosa sp.—im, Sept. 28.

Pardosa sp.—im, Aug. 25; Oct. 6; Jan. 26.

Pirata sp.—im, Aug. 10; Dec. 7.

Thomisidae

Cariarachna versicolor Keyserling—im, Dec. 14.

Misumenops asperatus (Hentz)—im, July 2, 7; Aug. 3, 10, 17, 25, 31; Sept. 15, 22, 28; Oct. 6, 12, 19; Nov. 4, 10.
Philodromus sp.—im, Apr. 26.
Synema parvulum (Hentz)—im, Apr. 19; May 31; Sept. 22; Oct. 6, 12; Nov. 16, 26.
Tmarus sp.—im, Mar. 15, 22, 29.
Xysticus funestus Keys—ad, Aug. 3; Sept. 15, 22, 28; Oct. 6, 19.
Xysticus sp.—im, July 27; Aug. 3, 10, 17, 31; Sept. 5, 15; Oct. 6, 19, 26.
Gnaphosidae
Zolotes sp.—im, Apr. 5; Oct. 6; Dec. 14.
Anyphaenidae
Anyphaena sp.—im, Apr. 19; May 31; June 7; Sept. 28; Oct. 12, 19, 26; Nov. 10, 30; Dec. 7; Jan. 21.
Clubionidae
Clubiona pallens Hentz—ad, Sept. 22.
Clubiona sp.—im, June 21; July 20; Sept. 15, 22, 28; Oct. 12.
Phrurotimpus sp.—im, Dec. 14.
Salticidae
Hentzia sp.—im, Apr. 5, 12, 19; Sept. 22; Oct. 12, 19; Feb. 11; Mar. 22, 29.
Metaphidippus protervus (Walck.) im, ad, Apr. 5, 19; May 10; Oct. 12, 19; Nov. 10.
Metaphidippus exiguus (Banks)—im, Apr. 26.
Metaphidippus galathea (Walck.)—im, Oct. 12, 19.
Metaphidippus sp.—im, Sept. 22.
Maevia vittata (Hentz)—im, ad, Sept. 15, 28.
Paraphidippus marginatus (Walck.) im, ad, Apr. 19; Aug. 25; Oct. 6.
Paraphidippus crysis (Walck.)—ad, Dec. 7.
Pellenes decorus Bl.—ad, Aug. 25.
Pellenes sp.—im, Sept. 28.
Phidippus audax (Hentz)—im, ad, July 27; Oct. 6, 12, 19.
Phidippus sp.—im, May 10, 31; June 14, 21; July 27; Aug. 3, 10, 31; Sept. 15, 22; Oct. 12, 19, 26.
Thiodina sylvana (Hentz)—im, ad, May 31; July 20; Aug. 3, 10, 17, 25, 31; Sept. 22; Oct. 6, 12.
Zygoballus bettina (Peckham)—im, ad, June 21; Sept. 28; Oct. 6.
Phalangida, Phalangiidae
Leiobunum crassipalpe Banks—ad, June 30; Aug. 3, 10, 17; Sept. 15.
Acarina, Ixodidae
Dermacentor variabilis (Say)—ad, Jan. 27.
Erythraeidae
Leptue sp.—ad, Sept. 22.
Thrombidiidae
Allothrombium missouriense Ewing—ad, June 21; Sept. 15, 22, 28; Nov. 4.
Trombidium locustarum Riley—ad, June 21; Oct. 6; Nov. 25, 30; Dec. 7; Jan. 25; Mar. 22.
Myriapoda, Diplopoda
Polydesmidae
Brachydesmus galdiolus (Williams and Hefner)—ad, June 30.
Polydesmus monoliaris Koch—ad, Jan. 14.
Scytonotus granulasus Say—ad, July 6.
Julidae
Diploiulus londinensis Leach, var. *caerulolocinstus* Wood—ad, Mar. 3; Jan. 12.
Diploiulus luscus Meinert—ad, June 30; July 27.
Parajulus impressus Say—im, Apr. 26.
Parajulus sp. prob. *impressus*—im, July 20; Nov. 30; Dec. 14.
Chilopoda, Geophilidae
Arenophilus bipuncticeps Wood—ad, Apr. 5, 19; May 17, 25, 31; Aug. 3, 10, 17, 25; Sept. 22, 28; Oct. 6, 12; Dec. 14, 21; Feb. 22.
Scolopendridae

Cryptops hyalinus Say—ad, June 14.
Theatops sp.—ad, Dec. 30.
Lithobiidae
Lithobius bilabiatus Wood—im, ad, July 27; Aug. 25; Sept. 15; Dec. 27; Feb. 22; Mar. 15, 29.
Lithobius pullus Bollman—ad, Aug. 25, 31.
Insecta, Orthoptera
Mantidae
Stagmomantis carolina (Johannson)—ad, Sept. 28.
Tetrigidae
Acridium arenosum angustum Hancock—ad, Sept. 22.
Tettigidea lateralis (Say)—ad, July 6, 14, 27; Aug. 10, 25; Oct. 26; Jan. 12.
Acrididae
Arphia xanthoptera (Burm.)—ad, Aug. 10.
Arphia sp.—ad, Aug. 10; Feb. 2.
Chortophaga viridifasciata Saussure—ad, Aug. 10.
Dichromorpha viridis (Sciedder)—im, July, 6, 1.
Dissosteira carolina (Linn.)—ad, Aug. 25.
Melanoplus bivittatus (Say)—ad, Oct. 31.
Melanoplus differentialis Thomas—im, ad, July 14; Aug. 25; Sept. 5, 22.
Melanoplus femur-rubrum (DeGeer)—im, ad, July 6, 14, 27; Aug. 3, 10, 17, 25, 31; Sept. 5, 15, 28; Oct. 6, 12, 19, 26; Nov. 10.
Melanoplus scudderi (Uhler)—ad, Oct. 10.
Syrbula admirabilis (Uhler)—im, Aug. 3; Sept. 5.
Amblycorypha oblongifolia (DeGeer)—ad, July 27.
Orchelium vulgare Harris—ad, July 6; Aug. 10, 17, 25; Sept. 5, 15, 22, 28; Oct. 6.
Scudderia furcata Brunner—ad, Sept. 5; Oct. 6.
Gryllidae
Nemobius sp.—ad, July 27; Sept. 15; Aug. 25; Dec. 21.
Hemiptera, Miridae
Deraeacoris nebulosus (Uhler)—ad, Oct. 19.
Lygus oblineatus (Say)—ad, Apr. 5; May 31; June 7, 14; July 6, 14; Aug. 17; Sept. 5, 28; Oct. 6, 12, 19; Nov. 4, 10, 16, 25, 30; Dec. 7, 14, 27; Jan. 12, 26; Feb. 15, 22; Mar. 15, 22.
Miris dolobratus (Linn.)—ad, May 31.
Anthocoridae
Orius insidiosus (Say)—ad, Sept. 22; Oct. 6, 12, 19; Nov. 4.
Nabidae
Nabis ferus (Linn.)—ad, Aug. 3.
Nabis sordidus Reuter—ad, July 14, 20, 27; Aug. 3; Sept. 28.
Reduviidae
Acholla multispinosa Deg.—ad, Oct. 19.
Melanolestes picipes (H.-S.)—im, ad, Aug. 3.
Oncerotrachelus acumenatus Say—ad, Sept. 28.
Pselliopus cinctus (Fab.)—ad, Feb. 22.
Zelus exsanguis (Stal.)—im, July 27; Sept. 5; Oct. 6, 12; Nov. 10; Jan. 21, 26; Feb. 22.
Tingidae
Corythucha arcuata (Say)—ad, Oct. 6.
Corythucha marmorata Uhler—ad, Sept. 28; Oct. 6.
Corythuca ulmi O.—ad, Sept. 15; Oct. 26.
Leptoypha mutica (Say)—ad, Sept. 28.
Lygaeidae
Blissus leucopterus (Say)—ad, Nov. 10.
Cymus angustatus Stal.—ad, (No date).
Malezonotus rufipes Stal.—ad, (No date).
Mydocha serripes Oliv.—ad, Dec. 7.
Oedancala dorsalis (Say)—ad, May 17, 25, 31; June 7, 14; July 14.

Ozophora picturata Uhler—ad, May 31.

Neididae

Jalysus spinosus Say—ad, July 14, 20, 27; Aug. 3, 10, 25, 31; Sept. 15; Oct. 6, 12, 19; Nov. 30; Dec. 21.

Coreidae

Acanthocephala terminalis (Dallas)—ad, Apr. 12; July 27.
Acanthocephala femorata Fab.—ad, July 14.
Arhyssus lateralis (Say)—im, ad, Sept. 22.
Euthochtha galeator (Fab.)—im, July 6.
Leptoglossus oppositus (Say)—im, Ec. 27.
Liorhyssus hyalinus (Fab.)—im, Nov. 16.

Pentatomidae

Euschistus servus (Say)—im, Oct. 19.
Euschistus tristigmus (Say)—im ad, July 20; Sept. 22, 28.
Euschistus tristigmus pyrrhocerus (H.-S.)—ad, July 20.
Euschistus euchistoides (Voll.)—ad, May 17, 25, 31; June 7, 14, 21, 30; Aug. 3, 31; Sept. 15, 22, 28; Nov. 30.
Euschistus variolarius P. B.—ad, Oct. 19, 26; Nov. 30.
Homaemus parvulus (Germar)—im, Aug. 10.
Hymenarcys aequalis (Say)—im, Aug. 10.
Hymenarcys nervosa (Say)—ad, Sept. 22.
Mormidea lugens (Fab.)—ad. Sept. 5.
Neottiglossa cavifrons Stal.—ad, May 25.
Podisus maculiventris (Say)—ad, July 14; Nov. 30; Feb. 1, 11.
Stethaulax marmoratus (Say)—ad, Ec. 7.
Thyanta accerra McAtee—ad, Nov. 16.
Thyanta custator (Fab.)—im, Aug. 25; Oct. 19.

Cydnidae

Corimelaena pulicaria (Germar)—ad, May 10, 17, 31; June 7, 21; July 6, 14; Aug. 3, 10, 17; Sept. 5, 15, 22, 28; Dec. 7; Jan. 26; Feb. 15.
Galgupha ovalis Hussey—ad, Sept. 15.

Homoptera, Ceropidae

Clastoptera xanthocephala unicolor Fowler—ad, Oct. 19; Dec. 27.
Lepyronia quadrangularis (Say)—im, ad, Apr. 5; July 6, 14, 20, 27; Aug. 10, 17, 25, 31; Sept. 5, 15, 22, 28; Oct. 6, 12, 26; Nov. 10, 30; Dec. 7; Jan. 26.

Membracidae

Acutalis nigrinervis (Fowler)—ad, Oct. 12.
Ceresa sp.—ad, Oct. 12.
Camphlenchia latipes Say—ad, July 6; Aug. 10, 17, 31; Sept. 5.
Micruatlis calva (Say)—ad, June 7; Oct. 12.
Vanduzea trigutta Burm.—ad, Aug 17; Sept. 15, 22.

Cicadellidae

Aceratagallia sp.—ad, Aug. 3, 31; Sept. 22.
Acinopterus acuminatus V. D.—ad, Sept. 28.
Agallia constricta V. D.—ad, Aug. 31.
Aulacizes irrota (Fab.)—ad, July 6, 14.
Athysanella sp.—ad, Sept. 22.
Cixcadella hieroglyphica Ball—ad, July 14, 27; Aug. 3.
Balclutha punctata (Thnb.)—ad, Oct. 12.
Chlorotettix glabanatus Baker—ad, July 20.
Chlorotettix melanotus Del.—ad, Sept. 22.
Chlorotettix spatulatus Osb. and Ball—ad, July 6; Sept. 22.
Chlorotettix tunicatus Ball—ad, July 6; Sept. 15.
Chlorotettix viridis V. D.—ad, Aug. 31.
Ciminius hartii (Ball)—ad, Sept. 22.
Deltocephalus sp.—ad, Sept. 28.
Dikraneura sp.—ad, Sept. 22.
Doleranus longulus (G. & B.)—ad, Oct. 12.

Draeculacephala mollipes Say—ad, July 6, 14, 20, 27; Aug. 3, 17, 25, 31; Sept. 15, 28; Oct. 6, 12, 19; Nov. 4.
Draeculacephala sp.—ad, Sept. 15, 22.
Empoasca bifurcata Del.—ad, Sept. 22.
Erythroneura accola McAtee—ad, Sept. 28.
Erythroneura nigra (Gill)—ad, Sept. 28; Oct. 12.
Farcipata sp.—im, Sept. 15, 22; Dec. 7.
Graphocephalus versutus (Say)—ad, Sept. 15; Oct. 12.
Gypona sp.—ad, Oct. 6.
Idiocerus sp.—ad, Jan. 26.
Jassus olitorius (Say)—ad, June 14; July 6; Aug. 3, 31.
Kolla bifida Say—ad, June 15; Sept. 15.
Latalus sayi (Fitch)—ad, Sept. 22.
Macrasteles divisus (Uhler)—ad, Apr. 19; Sept. 22.
Paraphlepsius irroratus (Say)—ad, July 14, 20, 27; Aug. 3, 17; Sept. 5, 15.
Phlepsius borrori D. & L.—(No date).
Phlepsius rufusculus Osb. & Loth.—(No date).
Scaphoideus sp.—ad, Sept. 5.
Stirellus bicolor (V. D.)—ad, Aug. 17; Sept. 15, 22.
Stirellus obtutus (V. D.)—ad, Apr. 19; Aug. 31; Sept. 22, 28; Nov. 16.

Acanaloniidae

Acanalonia bivittata (Say)—ad, July 14.

Fulgoridae

Stenocranus brunneus Beamer—ad, Sept. 15, 22; Nov. 16.

Aphididae

Macrosiphum eupatorii (Williams)—ad, May 10; Sept. 22, 28; Oct. 6, 12, 19, 26.
Phylloxera rileyi Riley—ad, Sept. 15.

Cixiidae

Myndus pictifrons Stal.—ad, June 30.

Issidae

Bruchomorpha oculata Newm.—ad, Aug. 25.

Coleoptera, Carabidae

Anisodactylus nigerrimus (Deg.)—ad, Aug. 31.
Agonum (*Circinalia*) *punctiformis* Say—ad, Dec. 7; Jan. 12.
Agonoderus comma Fab.—ad, June 21; Jan. 26; Feb. 1.
Ardistomis viridis Say—ad, June 7; Dec. 14.
Amora sp.—ad, Jan. 26.
Pterosticus (*Omaselus*) *femoralis* Kby.—ad, Aug. 17; Jan. 12, 21.
Harpalus longior Kby.—ad, Jan. 26.
Peterostichus (*Abacidus*) *permundus* Say—ad, July 27.
Pterostichus (*Poecillus*) *lucublandus* Say—ad, Jan. 21.
Pterostichus (*Evarthrus*) *seximpressus* Lec.—ad, Sept. 22.
Lebia ornata (Say)—ad, July 20.
Stenolophus conjunctus Say—ad, Jan. 21.
Tachistodes pauperculus Kby.—ad, Apr. 19; Sept. 22.

Staphylinidae

Linolathra filiaris Csy.—ad, Jan. 1.
Micromaseus desidiosus (Lec.)—ad, Sept. 28.
Mycetoporus humidus Say—ad, July 14.
Pinophilus parvipennis Csy.—ad, Jan. 21.
Staphylinus sp—ad, Mar. 15.
Stilicus biarmatus Lec.—ad, Dec. 14.

Nitidulidae

Stelidota octomaculata Say—ad, Jan. 21.

Erotylidae

Languria mozardi Latr.—ad, Apr. 5.

Malachiidae

Collops quadrimaculatus Fab.—ad, May 17.

Cleridae
Enoclerus rosmarus Say—ad, June 21.
Hydnocera humeralis Say—ad, May 31; June 21.
Mordellidae
Mordella oculata Say—ad, July 20.
Meloidae
Cantharis bilineatus Say—ad, May 10.
Anthicidae
Anthicus cervalis Laf.—ad, Apr. 19.
Anthicus sensu latitudine sp.—ad, Apr. 19.
Notoxus bicolor Say—ad, Aug. 25; Jan. 26.
Notoxus monodon Fab.—ad, Mar. 29.
Elateridae
Drasterius dorsalis Say—ad, May 17.
Limonius griseus Beaur.—ad, June 7.
Buprestidae
Brachys aerosus Melsh.—ad, May 17.
Lathridiidae
Melanophthalma distinguendus Com.—ad, Jan. 12.
Melanophthalina picta Lec.—ad, Sept. 28.
Phalacridae
Acylomus ergoti Csy.—ad, Apr. 19; Sept. 27.
Coccinellidae
Anatis 15-punctata (Oliv.)—ad, June 7.
Anatis quindecimpunctata Oliv.—ad, Oct. 19.
Chilocorus bivulnerus Muls.—ad, Nov. 16.
Cycloneda sanguinea (Linn.)—ad, May 10; June 7, 21; July 6, 27; Sept. 15; Oct. 12, 26.
Cycloneda munda Say—ad, June 21.
Ceratomegilla fuscilabris Muls.—ad, May 17, 25, 31; June 7, 14, 21; Oct. 6.
Hippodamia convergens Guer.—ad, May 17, 31; June 7, 14, 21.
Hippodamia parenthesis (Say)—ad, June 30.
Psyllobora virginti-maculata (Say)—ad, Sept. 15.
Scymnus terminatus Say—ad, July 6; Sept. 22.
Scymnus agricola Csy.—ad, July 6.
Scarabaeidae
Ataenius strigatus Say—ad, Dec. 14.
Ataenius spretus Hald (Consors Fall)—ad, Sept. 22; Oct. 16.
Canthon perplexus Lec.—ad, Jan. 12.
Orthophagus cribicollis Horn—ad, Dec. 27.
Orthophagus hecate Panz.—ad, Dec. 27.
Chrysomelidae
Anoplitus inaequilis (Web.)—ad, Sept. 15.
Aphthona insolita (Melsh.)—ad, Sept. 22; Oct. 6.
Altica sp.
Chaetocnema obsula Lec.
Chaetocnema pulicaria Melsh.—ad, Sept. 22, 28; Oct. 6.
Cerotoma trifurcata Forst.—ad, June 21; July 20.
Crepidodera atriventris Melsh.—ad, Sept. 28; Nov. 16.
Crepidodera nitens Horn—ad, Sept. 22.
Diabrotica vittata (Fab.)—ad, Oct. 19.
Diabrotica 12-punctata (Fab.)—ad, May 17; July 6, 27; Aug. 25; Sept. 5, 28; Oct. 19, 26; Nov. 4, 30.
Epitrix brevis Sz.—ad, Sept. 22.
Epitrix fuscula Cresson—ad, Sept. 22; Jan. 26.
Longitarsus turbatus Horn—ad, Sept. 22, 28.
Myochrous denticollis (Say)—ad, Sept. 22.
Oedionychis vians (Ill.)—ad, Aug. 3; Nov. 4.

Oedionychis vians scripticollis Say—ad, Jan. 12.
Oedionychis scalaris Melsh.—ad, July 6.
Oedionychis thyamoides Cresson—ad, Jan. 14.
Orchrosis atriventris Melsh.—ad, Mar. 22.
Paria canella (Fab.)—ad, Sept. 28.
Paria canella quadrinotata (Say)—ad, Oct. 6.
Phaedon sp.—ad, Oct. 19.
Phyllotreta zimmermonni Cresson—ad, Mar 22.
Rhabdopterus picipes Oliv.—ad, July 20, 27.

Mylabridae
Mylabris obtectus Say—ad, Aug. 10.

Curculionidae
Apion griseum Smith—ad, Apr. 19.
Aulobaris sp.—ad, July 27.
Calandra oryzae Linn.—ad, Jan. 12.
Ceutorhynchus sulcipennis Lec.—ad, Sept. 5.
Cryptorhynchus pumilus Boh.—ad, Sept. 22.
Conotrachelus posticatus Boh.—ad, Jan. 12.
Curculio baculi Chttn.—ad, Aug. 25.
Eurhoptus sp.—ad, Jan. 26.
Gelus oculatus (Fall)—ad, Sept. 22.
Hypera punctata (Fab.)—ad, Aug. 31; Sept. 15.
Hyperodes sp.—ad, May 25.
Pandeleteius hilaris Hbst.—ad, Jan. 12.
Pelenomus sp.—ad, Oct. 12.
Pseudobaris nigrina (Say)—ad, Sept. 22.
Spilota marginata Fab.—ad, June 21.
Sitona hispidulus (Fab.)—ad, Aug. 25.

Diptera, Sepsidae
Sepsis punctum (Fab.)—ad, Sept. 22.

Drosophilidae
Scaptomyza adusta (Lw.)—ad, Sept. 22.
Scaptomyza graminum (Fallen)—ad, Sept. 22.

Chloropidae
Hippelates particeps (Beck.)—ad, Sept. 22.
Oscinella painteri Sabr.—ad, Sept. 22.
Oscinella carbonaria (Lw.)—ad, Sept. 22.
Thaumatomyia glabra (Meig.)—ad, Sept. 22.

Anthomyzidae
Mumetopia occipitalis (Mel.)—ad, Sept. 22.

Muscidae
Linophora sp.—ad, Sept. 22.

Hymenoptera, Braconidae
Aspilota sp.—ad, Oct. 6.
Cratospila sp.—ad, Sept. 28.
Heterospilus sp.—ad, Sept. 22.
Macrocentrus delicatus (Cresson)—ad, Oct. 12.
Meteorus humilis (Cresson)—ad, Oct. 12.
Synaldis sp.—ad, Oct. 6.

Ichneumonidae
Ceroptres sp.—ad, Sept. 28.
Coccygominus aequalis (Prov.)—ad, July 27.
Colpognathus helvus (Cresson)—ad, July 27.
Ischnus fraterculus (Prov.)—ad, Sept. 22.
Mesochorus dicitergus (Say)—ad, Sept. 15.
Proclitus sp.—ad, Oct. 6.
Sternomacrus sp.—ad, Oct. 12.
Zaleptopygus sp.—ad, Sept. 28.

Eulopidae
Galeopsomyia sp.—ad, Sept. 15.
Diapriidae
Xenotoma sp.—ad, Oct. 6.
Formicidae
Crematogaster lineolata (Say)—ad, June 30; July 27; Aug. 25; Sept. 5, 22, 28; Oct. 6; Dec. 14.
Camponotus carye Fitch—ad, Sept. 22, 28.
Ponera coarctata pennsylvanica Emery—ad, July 20; Aug. 3, 10; Sept. 5; Dec. 21.
Pronolepsis imparis (Say)—ad, Sept. 28.
Solenopsis molesta (Say)—ad, July 6, 14; Sept. 15, 22; Oct. 6.
Tapinoma sessile Say—im, ad, May 17, 25; Sept. 22, 28; Jan. 12.

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Acrocanthosaurus atokensis, a New Genus and Species of Lower Cretaceous Theropoda From Oklahoma

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ABSTRACT

A new genus and species of aberrant Theropoda based on remains of two individuals from the Trinity sands of southeastern Oklahoma is described. All important parts of the skeletons are represented and indicate an animal of exceptional size. The genus is characterized by greatly elongated and massive neural spines in allusion to which the generic name *Acrocanthosaurus* is proposed. In general, the skeletal features indicate a large rather advanced carnosaur, which, however, had not yet reached the high degree of development present in the Upper Cretaceous deinodonts. The relationships to other long-spined forms are discussed. Despite marked similarities to certain members of the Megalosauridae, the present genus appears most closely allied to the Allosauridae.

The status of *Altispinax* is discussed.

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INTRODUCTION

In the Spring of 1940, reports of the presence of numerous large bones in Atoka County, Oklahoma, were received by the senior author. In April of that year, the writers, in company with Dr. C. N. Gould, former director of the Oklahoma Geological Survey, visited the location and found a considerable part of the skeleton of a large Trinity carnivorous dinosaur. The bones were on the farm of Mr. Herman Arnold in the southeast part of the southwest quarter of Section 26, Township 4 South, Range 14 East.

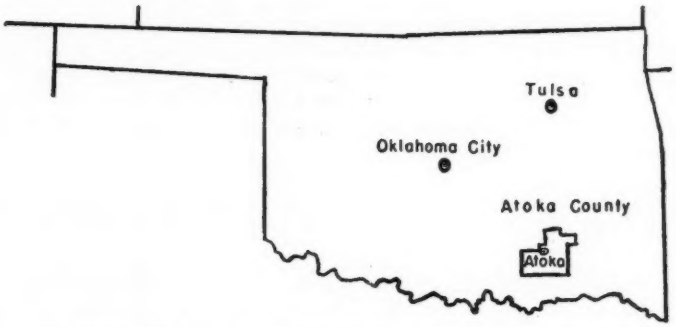

Fig. 1.—Index map of Oklahoma showing the area with which this paper is concerned.

Excavation was made by a Works Progress Administration crew under the direction of the senior author. Further exploration was carried on by the crew and a second skeleton was found on the section line three quarters of a mile east on the land of Mr. W. P. Cochran. It is with this and the specimen from the Arnold farm that this paper is concerned.

Exploration was continued intermittently during the excavation period of 1940 and 1941. In that time, partial dinosaur skeletons were found at nine other places in this township.

Owing to the difficulties of carrying on field work during World War II and because the junior author was serving in the Navy, the project was discontinued until his return to the University in 1945.

While these are not the first dinosaur remains found in the area, they are the most important. Pierce Larkin (1910) described a coracoid of a large sauropod from the Trinity (Lower Cretaceous). The bone was found about 25 miles almost due west of the location of the type. Since that time, but prior to the present discoveries, no vertebrate remains have been reported from the Lower Cretaceous deposits of the area. However, several subsequent discoveries of dinosaurian remains have been made in beds of Trinity age in Texas, but none have as yet been described.

The area is a difficult one to work because of the scarcity of passable roads

and its forested condition. Culture and drainage maps of 27 of the 36 sections were prepared, section by section.

Many authors have observed that the Trinity overlaps, unconformably, the Pennsylvanian beds and is conformably overlain by the Goodland limestone. The Trinity is generally described as a beach or near-shore deposit, probably in part because of the presence of a conglomerate that may be of beach origin and is said to form a basal member. The senior author is of the opinion that much more study will be necessary before the question of the origin of the Trinity can be answered. There are several factors that are as favorable to a hinterland as to an off-shore origin for the sands of this group. The conglomerate that occurs at the base is more discontinuous than one would expect to find if it were a beach deposit. There are many lenses of blue or red clay, many fragments of fossilized wood, cycads and dinosaur bones, although the presence of interbedded limestones containing Lower Cretaceous marine fossils clearly indicate that the group was put down at or near the critical level of Lower Cretaecous seas.

Further south, the Trinity consists of the Travis Peak, Glen Rose and Pulaxy which, however, have not been identified in Oklahoma. The group dips at about 60 feet per mile and is about 500 feet thick, and the fossils in Section 26 were found about 120 feet below the top.

In this region, the Trinity can be distinguished from Quaternary stream deposits of sand with difficulty although it is generally more compact than the latter, has a more characteristic yellow cast and is more continuous. Toward the west and south, the Trinity becomes more white and on the Red River is a pure white sand. Resting on the surface, there are pebbles and a few cobbles of quartz and quartzite. Associated with the bones on the Cochran farm, there were pebbles of red and brown chert which may or may not be indigenous to the group. Taff (1902) believed that the "Quartz pebbles are foreign to the region, while the chert is local, being derived from the Talihini chert, near which it is most abundant in the vicinity of Black Knob Ridge." It is possible that the basal conglomerate of the Trinity was derived largely from the Talihini (Silurian) and that the surface pebbles are derived in turn from the basal conglomerate having been washed down slope by local streams. Some of the pebbles are polished and in that respect are suggestive of the so-called gastroliths of the Cloverly formation. One specimen (not described in this paper) was a nearly perfect skull of a dinosaur almost identical with one collected by the writers from the Cloverly formation on the Crow Agency, Montana. The Lower Cretaceous age of the Cloverly is thus confirmed. Authors assign the Trinity approximately to Petapsco time in Maryland and Delaware and the Upper Aptian and Lower Albian of Europe.

Neither skeleton described in this paper is complete, but there is little duplication of the individual elements. Where repetition does occur, however, the similarity between the individuals is striking. With the exception of the smaller size of the second specimen, which was probably a younger animal, no noteworthy differences between the two are apparent.

The more complete individual came from the Cochran farm and is desig-

nated as the type. It was embedded in a dark, red-brown, arenaceous shale. The bones were near the surface, most of them being covered by only a few inches of protective overburden. The entire area is heavily wooded, and consequently the skeleton has suffered from the penetration of tree roots.

The paratype was found in a fine yellow sand which locally contained masses of light gray clay nodules. This matrix is soft except around the bones themselves where it is extremely hard and difficult to work.

The preservation of both specimens leaves much to be desired. With few exceptions, there were no complete elements recovered. As a result, accurate measurement is practically impossible. However, a fairly complete understanding of the osteology of this unique reptile is furnished by the present specimens since, between the two, practically every part of the skeleton is represented. The following table lists all the more important bones:

TYPE—M.U.O. 8-0-S9	PARATYPE—M.U.O. 8-0-S8
Occiput	
Frontals	
Parietals	
Left jugal	
Left lachrymal	
Right squamosal	
Right postorbital	
Right ectopterygoid	
Articular portion of the left ramus	
Nine cervical vertbrae	
Six dorsal vertebrae	Two dorsal centra
Eight unattached dorsal spines	Four unattached dorsal spines
Two caudal centra	Thirteen caudal vertebrae
Three cervical ribs	
Five dorsal ribs	Eight dorsal ribs
One abdominal rib	
Two anterior chevrons	One anterior chevron
Left Coracoid	
Right and left pubes	Right and left pubes
Left ischium	
Distal end of the right femur	Proximal end of the left femur
Left tibia	Fragmentary left tibia
Right fibula	
Fragmentary left fibula	
Left astragalus	
	Left metatarsals II and III
	Left phalanx III (I)

GENERIC DIAGNOSIS

Order Surischia, Suborder Theropoda, Infraorder Carnosauria, Family Antrodemidae.

Acrocanthosaurus atokensis gen. et sp. nov.

This animal is a carnivorous saurischian of gigantic size and heavy proportions with massive and greatly elongated neural processes. The skull is of massive proportions, and the arcades are moderately heavy; orbits and postoribtal fenestra somewhat reduced; jugular foramen greatly enlarged; frontals and parietals solidly coosified and quadratosquamosal movement somewhat reduced; cervical centra opisthocoelous and of moderate length; pleurocentral cavities deep and well marginated; anterior dorsals distinctly opisthocoelous; medial caudals with supplementary neural processes; chevrons closed proximally by transverse bar, and exhibiting an anterior upward projecting process on each ramus; pelvic elements not coossified; pubis slender with broadly expanded distal termination; ischium straight, slender and elongate, somewhat expanded distally; tibia strongly bowed outward; metatarsal III somewhat constricted proximally by lateral elements.

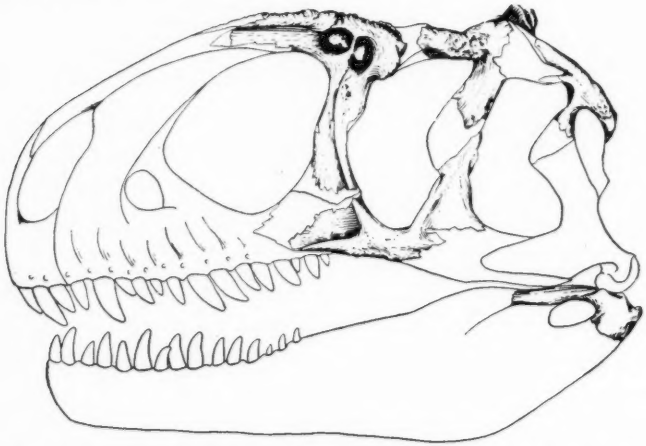

Fig. 2.—Restoration of the skull of *Acrocanthosaurus atokensis* gen. et sp. nov. Length of skull as restored about 896 mm. (restoration of the face and mandible, although based on comparison of several other large carnivorous dinosaurs, is hypothetical).

DESCRIPTION OF THE SKELETON

Skull.—The skull of *Acrocanthosaurus* is known only from remains of the type. The bones are, for the most part, well preserved although, as may be seen in Figure 2, the sutural areas are not generally complete. When found, the individual elements, with the exception of the occiput, frontals, and parietals, were disarticulated and widely separated; but careful comparison with the skulls of other large carnivorous dinosaurs has made their association and partial restoration possible.

In most instances, the developmental progressiveness as outlined by Gil-

more (1920), Osborn (1912), and others is clearly shown in the skull of *Acrocanthosaurus*, although the large antorbital fenestra and expanded prefrontal as restored by the present writers are somewhat at variance with the views of those authorities.

Frontals.—When viewed from above, the frontals are subtriangular in outline and appear somewhat wider than in *Antrodemus*. The median suture between the two elements is poorly discernible, except in the most anterior region. The smooth superior surface is flat with only a low arching above the orbit. The fusion of the frontals with the parietals is complete, the contact being marked by a moderately rugose area on the superior surface of the skull. Laterally, however, this suture is sufficiently well marked to permit ready definition. Posteriorly, the frontals are greatly expanded transversely, uniting ventrally with the alisphenoids and laterally with the postorbital complex.

Gilmore (1920) states that the frontals in *Antrodemus valens* are "almost entirely excluded from the upper external boundary of the orbit, by the postfrontal and prefrontal bones." The prefrontals in *Acrocanthosaurus*, however, must have been of different proportions than those in *Antrodemus* and probably completely obscured the frontals in lateral aspect. Further evidence in support of this conclusion is furnished by the lateral edges of the frontals themselves which, although damaged, show indications of sutural contacts with other elements along their entire length.

Parietals.—When seen from above, the parietals are transversely expanded both anteriorly and posteriorly with a pronounced median constriction. The superior surface is slightly concave transversely, the raised lateral edges being separated from the almost vertical sides by a sharp antero-posterior angulation. There is no sagittal crest as in *Tyrannosaurus*. The bone exhibits no median suture, and the one between the frontals and parietals is indicated only by a slightly roughened surface above the line of contact. The dorsal extension of the supraoccipital crest is much less marked than in *Antrodemus*, and there is no supero-median notch as is seen in that genus. To the contrary, the superior edge of this crest in *Acrocanthosaurus* is transversely rounded and anteroposteriorly thickened at the summit. Laterally, the parietal appears as an almost vertical antero-posteriorly concave plate forming much of the median surface of the supratemporal fenestra.

Gilmore (1920) notes that in *Antrodemus* "the parietals are continued backward as a heavy overhanging, [the supraoccipitals], bluntly pointed projection." In the present skull, however, there is some question as to whether this projection actually belongs to the parietal or is part of the supraoccipital itself. At any rate, the lateral suture between the latter element and the parietal is clearly marked (there is no slender process interposed between the two elements as in *Antrodemus*) and appears to continue upward to the summit of the supraoccipital crest, in which case the parietal would be altogether excluded from the knob-like supraoccipital tuberosity.

Posteriorly, there is an elongate blade-like process that projects strongly outward and gently downward and backward overlapping the antero-superior surface of the paroccipital process.

Prootic.—The prootic is an elongate flattened element which partially separates the occipital and parietal regions of the skull. It bears a thin, blade-like, outwardly directed process which overlaps the antero-median surface of the paroccipital process with which it is solidly united. As in *Antrodemus* and *Tyrannosaurus*, it bounds the *foramen ovale* and the auditory fenestra. Whether the foramen for the exit of the seventh cranial nerve passes through the prootic, as in the majority of dinosaurs, or is only partially bounded by that element, as in *Antrodemus* and *Tyrannosaurus*, cannot be determined; but the writers are inclined to accept the latter condition as the more probable.

Jugal.—The jugal is sufficiently complete to give some idea of the size and shape of the orbit and lateral temporal fenestra. It is of the typical tri-radiate form, transversely thin, thickening ventrally below the orbit so that in this region the bone is triangular in cross section. The orbital border is more broadly rounded than in *Antrodemus*. The sharp ascending process, somewhat wider antero-posteriorly than in that genus, is directed slightly backward and tapers gently upward towards its union with the descending process of the post-orbital complex. The thin plate-like anterior portion is dorso-ventrally expanded and encloses an exceptionally large jugular foramen. The upper rim of this opening was evidently continuous with a longitudinal fossa on the outer surface of the lachrymal.

Lachrymal.—In lateral aspect, the lachrymal suggests the figure 7. It is more slender than in *Antrodemus*, the maxillary process being relatively longer and more highly constricted dorso-ventrally than in that genus. The rugose ridge-like superior edge exhibits no horn-like supraorbital tuberosity, but above the antorbital angle of the lachrymal and suturally united with it, there is a flattened rugosity slightly suggestive of a horn core. Two deep pneumatic cavities, of which the posterior one is somewhat the larger, are situated in the antorbital angle in much the same position as in other large carnosaurs. In outline, the inferiorly directed process forming the separation between the orbit and the large antorbital fenestra is a reversed sigmoid curve, its distal portion antero-posteriorly expanded and transversely flattened. On the outer surface of this process, there is a longitudinal furrow which opens anteriorly. It is deep superiorly, becoming more shallow below, but apparently was continuous with the upper edge of the jugular foramen when the jugal and the lachrymal were articulated. A similar fossa occurs in the lachrymals of both *Antrodemus* and *Ceratosaurus*, but in neither of these is it prolonged so far distally as in *Acrocanthosaurus*.

The imperfectly preserved lachrymal, when considered by itself, bears some resemblance to the homologous element in *Antrodemus*. However, when attempting to place it in the restoration of the skull, it was found to occupy a somewhat different position in relation to the other bones of the face. It was impossible to orient the bone as in *Antrodemus* and still retain the smoothly rounded antero-ventral border of the orbit. In placing it in juxtaposition to the jugal so that an acceptable relationship between the two bones was obtained, the forwardly directed maxillary process was elevated so that the front part of the skull was apparently disproportionately deepened in a dorso-ventral direction.

Postorbital Complex.—The postfrontal and postorbital are solidly fused, forming the massive postorbital complex. This bone is by far the most robust and massive element in the skull, being dorso-ventrally thickened and solid throughout. The upper part forms much of the roof of the orbit, overhanging that opening in a heavy eave-like brow-ridge. Although considerably roughened and tuberous above, there is no orbital rugosity as seen in *Tyrannosaurus*. The forwardly directed inferior process is expanded anteriorly so that it projects well into the orbital opening somewhat as in the deinodonts.

The sutural surfaces are dorso-ventrally thickened with the most anterior one facing directly forward. This condition differs markedly from that found in *Antrodemus*. Since no opposing surface is visible on the lachrymal of *Acrocanthosaurus*, it is concluded that this area on the postorbital complex must have been in contact with the prefrontal, which would then be interposed between the former elements; and consequently no pronounced supraorbital notch, as occurs in *Antrodemus*, would have been present.

Squamosal.—The squamosal is an irregular-shaped bone similar in outline to that of *Antrodemus* but differs from the corresponding bone in that genus in several important particulars. It is proportionately smaller with a greater antero-posterior expansion of the anteriorly directed inferior process. This expansion projects into the lateral temporal fenestra and results in some reduction in the size of that opening. The surface for the acceptance of the upper articular end of the quadrate is concave but is divided medially by a low antero-posterior ridge. The squamosal was not united with the quadrate, but the articular surface of the former would have permitted less movement between the two elements than in *Antrodemus*. There is evidence of the development of exostotic material in this articular cup which, if continued into later life, would have caused even greater restriction of the temporal movement.

Posteriorly, an elongate, flattened, process directed inward, upward, and slightly forward overlapping the antero-superior surface of the paroccipital process.

Basioccipital.—The basioccipital contributes largely to the formation of the smooth knob-like occipital condyle. However, due to the completeness of the coalescence of the bones in this region, it cannot be determined whether the condyle is composed entirely of this bone. A long narrow median process, more slender than in *Antrodemus*, extends downward from the condyle and unites laterally with the plate-like exoccipitals and the basisphenoids.

Exoccipitals and Paroccipitals.—When observed from behind, the exoccipitals appear as broad plates which, together with the paroccipitals, form much of the posterior aspect of the occiput. A median suture above the *foramen magnum* shows that the exoccipitals form the upper margin of that opening. The exact degree to which these bones contribute to the ventral border of the *foramen magnum* or to the upper part of the occipital condyle cannot be determined.

The wing-like paroccipital processes project strongly outward and backward and, in general, resemble very closely those elements in *Antrodemus* but are relatively shorter and somewhat more massive than in that genus. Later-

ally, on either side of the occipital condyle, there is a deep pit, in the upper part of which are the foramena for the exit of cranial nerves IX, XI, and XII.

Supraoccipitals.—The supraoccipitals form a large, vertically ovate, tuberous mass which project backward and may be readily seen in the lateral view of the articulated skull. They are solidly united with each other along the midline of the skull and are interposed between the parietals and join the exoccipitals ventrally. They are excluded from the border of the *foramen magnum* by the median junction of the latter elements. Superiorly, the supraoccipitals are expanded transversely and project posteriorly in a large knob-like tuberosity which continues downward as a median ridge to a point just above the median exoccipital suture.

Alisphenoids.—The alisphenoids are large outwardly directed lateral elements which unite superiorly with the frontals and parietals and posteriorly with the prootics. Superiorly, a strong transverse process is developed at right angles to the vertical and antero-posterior axes of the skull. The knob-like outer termination of this process is received into a corresponding concavity on the inner side of the postorbital complex. The sutures between the alisphenoids and the adjacent elements have, for the most part, disappeared through the solid coalescence of the bones in this region of the skull.

Orbitosphenoids and Ethmoids.—Anterior to the alisphenoids and below the frontal, there is an elongate, lateral, plate-like bone which encloses the foramen for the first cranial nerve. It appears to have been divided by a vertical suture into an anterior and posterior segment. The posterior element seems to represent the orbitosphenoid. If such is the case, the anterior bone, following Osborn (1912), is considered as being a probable ethmoid. No evidence of the presence of a presphenoid, as represented by Osborn (1912) in *Tyrannosaurus,* has been found in the material under consideration; but, as previously remarked, the sutural pattern of this cranium is, at many places, totally obscured. The supposed presphenoid of Osborn is here considered to be the anterior portion of the orbitosphenoid.

The combined elements (ethmoid and orbitosphenoid) unite posteriorly and laterally with the alisphenoids, superiorly with the frontals, and medially with each other. As in *Tyrannosaurus,* there is a vertical septum dividing the exit of the olfactory foramen into two suboval halves. The exit for the second cranial nerve is ventral in that portion of the orbitosphenoid which as Osborn suggests may represent the presphenoid (Osborn, 1912). This foramen is considerably smaller than in either *Antrodemus* or *Tyrannosaurus.*

Basisphenoids.—The basisphenoid is similar to that in *Antrodemus.* It is composed largely of an extensive lateral plate which partially encloses a very deep, triangular, forwardly-opening, cavity. Although the anterior edges of these bones have been destroyed in the present specimen, it is evident from the portions remaining that this cavity was not as deep antero-posteriorly or as vertically elongate as in *Antrodemus.*

The parasphenoid is developed upward from the apex of this triangular opening much as in the skull of *Tyrannosaurus* but differs somewhat from that genus in relative length. Its anterior extension is unknown.

The antero-ventrally directed basipterygoid process of the basisphenoid is more elongate than in *Antrodemus* and is bent strongly outward and bluntly terminated.

Ectopterygoid.—The ectopterygoid is an irregular U-shaped bone not unlike the element figured by Gilmore (1920) for *Antrodemus valens*. The diameter of the large open space between the posterior branches is, however, considerably wider in the present form.

Lower Jaw.—The remains of the lower jaw are too inadequate to permit detailed description, but portions of the articular, surangular, and angular can be recognized. Very interesting and altogether unexpected, is the presence of a fenestra in the surangular which occupies a position similar to the opening seen in the lower jaws of *Gorgosaurus* and *Tyrannosaurus*. Only a small portion of the upper margin of this fenestra is preserved so that its size and shape cannot be determined with certainty.

MEASUREMENTS OF THE SKULL

	Millimeters
Lachrimal	
Length of maxillary process	240*
Length of inferior process	165*
Least antero-posterior diameter of inferior process	42
Postorbital complex	
Greatest dorso-ventral diameter supraorbital ridge	36
Length of inferior process	104*
Greatest transverse diameter of superior surface	91
Greatest antero-posterior diameter of inferior process	52
Jugal	
Least dorso-ventral diameter below orbital rim	47
Least transverse diameter of anterior end	1.5
Height of jugular foramen	43
Width of jugular foramen	13
Greatest height of ascending process	203
Width of ascending process at midlength	57
Greatest transverse diameter below orbit	41
Squamosal	
Transverse diameter articular cup	39
Antero-posterior diameter of articular cup	48
Antero-posterior diameter of inferior process	38
Length of parietals and frontals	227
Greatest transverse diameter of frontals	173
Transverse diameter of parietals (posterior)	185
Transverse diameter of parietals (anterior)	173
Least transverse diameter of parietals	34
Transverse diameter across alisphenoids	215
Height of skull from the basipterygoid process to top of frontals	260
Transverse diameter of *foramen magnum*	35
Vertical diameter of *foramen magnum*	27
Breadth across paroccipital processes	344

* Measurements of incomplete bone.

VERTEBRAL COLUMN

Cervical Vertebrae.—Of the ten more or less anterior presacral vertebrae preserved in the type specimen, nine belong to the neck. When found, only cervicals 8 and 9 and dorsal 1 were articulated, but the remaining seven vertebrae were closely associated with them. All of these bones are slightly distorted and damaged by tree roots and ground acids, but they are sufficiently well preserved to permit the accompanying restoration.

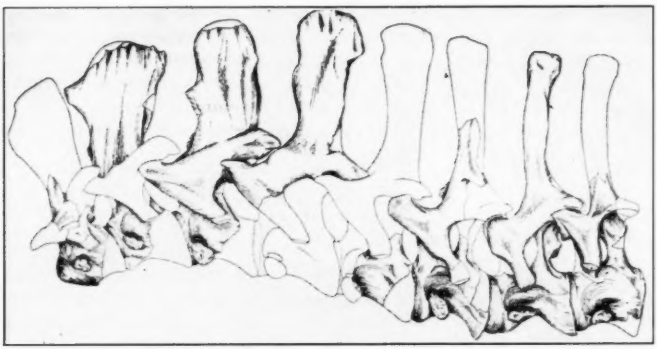

Fig. 3.—Cervicals 3 to 9 and dorsal 1 of *Acrocanthosaurus atokensis* gen. et sp. nov. about 1/9 natural size (for exact measurements see table on page 709).

Only a small fragment of the atlas, probably the intercentrum, was recovered. The axis is represented by a similar fragment. The neural canal was relatively larger than in the succeeding cervicals, and there is an indication of a well developed odontoid process.

The remaining cervicals are lightly constructed and exhibit exceptionally long spinous processes. The centra are strongly opisthocoelus, the anterior ball-like articular end almost filling the corresponding posterior concavity of the preceding element. They are somewhat longer than high, deeply excavated laterally, transversely expanded, being slightly wider than high, and, with the exception of the third, exhibit no indication of a ventral keel. The pleurocentral excavations are deep and sharply circumscribed. Laterally, a small oval foramen is situated just above the parapophysis in the deep anterior part of the pleurocentral cavity. This foramen, which apparently leads into the hollow of highly concellous interior of the centrum, becomes progressively larger and more elongate in each succeeding vertebra; but its relation to the parapophysis remains essentially the same throughout the series. Beginning with the sixth or seventh cervical, a second smaller ovate foramen appears, situated a few millimeters above and somewhat posterior to the larger one just described.

The diapophyses are elongate processes directed backward and strongly downward. In the more anterior vertebrae, they are applied laterally close to the centra and the neural arches and terminate well below the level of the

neurocentral suture. In the more posterior elements, however, these processes diverge with increasing sharpness from the body of the vertebrae and terminate progressively higher in relation to the neurocentral suture. They are supported and strengthened by oblique, buttressing laminae which arise both anteriorly and posteriorly just above the neurocentral plane and converge upwardly, finally meeting each other near the tubercular facet on the ventral surface of the diapophysis.

The parapophyses are broad, rounded, processes that project strongly outward from the lower part of the centra. They are less elongate than in *Antrodemus*, and when seen from the side they exhibit a marked change in position in the articulated series. On the third cervical, the parapophysis is situated well up on the side of the centrum and just posterior to the lip-like rim of the anterior articular surface. The capitular facet faces directly outward. In the medial section of the neck, it increases greatly in size and shifts downward so that in some instances more than one-half of the area of the capitular facet appears below the ventral border of the centrum. Posteriorly, however, it returns to a somewhat higher position but still remains well below the center of the centrum. In cervicals 7, 8, and 9, the parapophyses project strongly backward and the capitular facets look outward, backward, and somewhat downward.

The neural canal is relatively small throughout the series, its height only slightly exceeding its transverse diameter.

Laterally, the neural arches are plate-like and of moderate length. They are transversely thickened in the center, resulting in a moderate constriction of the neural canal at this point. In cervicals 7, 8, 9, there is, in addition to the oblique diapophyseal laminae mentioned above, a strong vertical bar which arises from the posterior part of the neurocentral area and joins above with the downward directed median portion of the posterior zygopophyses. It forms the posterior border of a vertically elongate opening which apparently passes through the sides of the neural arches into the neural canal just posterior to the parapophysis.

The prezygopophyses are large massive processes, the flat articular surfaces of which look upward and inward. In all cervicals posterior to the axis, they overhang the centrum; but their forward projection diminishes towards the base of the neck, and in the ninth the anterior termination almost coincides with the anterior end of the centrum.

The postzygopophyses overhang the centra but to a somewhat lesser degree than in *Antrodemus*. Well-developed epipophyses are present on the superior surfaces of the postzygopophyses. They are most noticeable on the fifth cervical where they project backward well beyond the posterior termination of the postzygopophyses. The epipophyses diminish rapidly in prominence towards the base of the neck and disappear altogether with the ninth cervical.

The neural spines of *Acrocanthosaurus* are the most striking feature of the entire skeleton. Those of the anterior cervicals are broad flat plates of bone varying in length from two to almost three times the height of the vertebral centra. They become broader in succeeding vertebrae, reaching their maxi-

mum expanse in number 6. In this vertebra, there is a rather sudden transition from the broad plate-like process of the more anterior elements to a more elongate, antero-posteriorly constricted spine with a rounded and broadly expanded summit. Posterior to the seventh cervical, the general form again changes abruptly. The spines become greatly thickened transversely and increase slightly in length. Concurrent with the increase in length, there is a marked decrease in the antero-posterior dimension. The resulting slender-pointed processes are altogether unlike the spines of any other known carnosaur. In cross section, the spines of cervicals 7, 8, and 9 are broadly U-shaped at the base and subround at the summit. They are inclined slightly forward, an adaptation doubtless required to facilitate upward movement of the neck.

In addition to the spines, numerous other less spectacular differences between the cervical vertebrae of *Acrocanthosaurus* and those of other carnosaurs are worthy of mention. The pronounced opisthocoelous character, the elongation of the centra, a more open and lighter constriction, and the sharply circumscribed pleurocentral excavations readily distinguish these cervicals from those of the later Upper Cretaceous deinodonts. The latter generally exhibit a flattened opisthocoelous type of articulation, a reduction in length of the centra, a corresponding increase in the height of the centra, more massive proportions, and a more solid construction.

Differences from Jurassic theropods are less pronounced. The cervicals of *Acrocanthosaurus* may, however, be distinguished from those of *Antrodemus valens* by the greater elongation of the centra and a corresponding decrease in height resulting in a somewhat more slender appearance in the former genus. The neural arches are not as broad antero-posteriorly as in the Morrison form, and the pleurocentral cavities are somewhat deeper and more sharply circumscribed. The diapophyses are more elongate, and the parapophyses project outward to a slightly greater degree than in *Antrodemus*. The opisthocoelous character, although developed equally in both forms in the anterior and medial cervicals, diminishes more rapidly towards the base of the neck in *Antrodemus*. In the Trinity animal, the posterior cervicals exhibit a strong opisthocoelous character suggestive of the condition present in *Megalosaurus* (*Streptospondylus*) *cuvieri* (Owen) from the Malm of England.

The criteria listed above for distinguishing *Acrocanthosaurus* from *Antrodemus* are equally applicable to the true European megalosaurs, although the centra in the present form are proportionately less elongate than in that group. The resemblance between the Oklahoma genus and *Megalosaurus* (*Streptospondylus*) *cuvieri* (Owen) is striking, although the centra in the present form are relatively lower than in that genus. The depth and margination of the pleurocentral cavities and the persistence of the opisthocoelous nature are practically identical in the two forms. The neural arches, however, are much more narrow antero-posteriorly in the present animal.

Similarity to the cervicals of *Spinosaurus aegyptiacus* Stromer is considered of little diagnostic importance. All other bones of the two animals are so dissimilar that any resemblance in isolated parts of the skeletons is coincidental and of no diagnostic value.

The number of cervical vertebrae in *Acrocanthosaurus* is unknown, but it is assumed to have been nine as in related genera. The break between the cervicals and the first dorsal is much more gradual than in those forms.

MEASUREMENTS OF THE CERVICAL VERTEBRAE (in mm.)

Vertebra	Length of Centrum	Height of Centrum	Height of Spine
3	96	66	.....
4	98	73	214
5	123	87	200
6	.....	.....	242
7	153	83*	.....
8	158	117	.....
9	168	115*	291

* Measurements of incomplete bone.

Dorsal Vertebrae.—The tenth presacral vertebra is provisionally identified as the first dorsal, but it might be more appropriately considered as a cervico-dorsal and transitional between the cervical and dorsal series. Like the cervicals, it is strongly opisthocoelous; and the centrum is longer than high. The parapophyses are set low on the sides of the centrum, and the diapophyses have not yet risen to a horizontal position. The pleurocentral excavations are deep and sharply circumscribed anteriorly with the two small foramena situated much as in the posterior cervicals. It is, however, in agreement with the dorsals in the higher position of the zygopophyses, neither of which overhangs the centrum. The diapophyses are situated relatively higher than in the preceding vertebra, and there is a suggestion of the presence of a hyposphene on the post-zygopophyses. The anterior zygopophyses are robust, upwardly directed processes, the articular surfaces of which look upward and only slightly inward, in marked contrast to those of the cervicals in which they slant sharply inward and downward. Although this is the last opisthocoelous vertebra preserved, the depth of the posterior cup indicates that the second dorsal also possessed this characteristic; and it appears probable that the condition continued as far back as the fourth or fifth, therein differing from *Antrodemus* where the opisthocoelous character is lost in the neighborhood of the second or third dorsal vertebra.

Of the remaining five vertebrae in the dorsal series, only three are sufficiently well-preserved to permit direct comparison with similar elements of other genera. Three of them appear to belong in the neighborhood of dorsals 6 to 9, while two large amphicoelous centra, possibly belonging to numbers 13 and 14, occupy a more distal position in the series.

The centrum of the sixth dorsal is plano-concave, while those posterior to it become progressively biconcave, finally reaching a pronounced amphicoelous condition in the two distal elements. All are deeply constricted laterally and ventrally and exhibit the pronounced flaring of the end typically present in other large theropods. The pleurocentral excavations are large and, although

moderately deep, are not well marginated. Each contains a longitudinally ovate foramen which is divided by a thin vertical lamina into two subequal halves. The anterior opening thus formed is decidedly the larger of the two and is situated slightly below the smaller one. All centra are higher than long, though the difference in these dimensions is not readily apparent in the more posterior elements. There is no definite neurocentral suture, but a rather persistent fracture in the vicinity of the base of the neural arch occurring in the three anterior vertebrae may indicate the position of this junction.

The parapophyses are located low on the sides of the neural arch, but, in all except the sixth, appear to lie well above the level of the neurocentral suture. They are robust, relatively longer than in *Antrodemus*, project strongly outward, somewhat downward, and terminate in a slightly expanded concave capitular facet.

The transverse processes are all incomplete, but supposedly they were directed sharply upward and somewhat backward in the anterior elements. Each was supported from below by a broad but thin lamina which arises abruptly from the superoposterior surface of the centrum. Another supporting lamina arises from the anterior and posterior zygopophyses and converges terminally, contributing greatly to the broad, flat, superior surface of the process.

The prezygopophyses are massive processes, the articular surfaces of which look directly upward. As mentioned above, each give rise laterally to a broad plate-like lamina which forms the anterior edge of the transverse process. Medially, they are separated by a deep vertical groove which receives a corresponding vertical blade-like process that projects downward from the posterior zygopophyses of the preceding vertebra.

The postzygopophyses are opposites of the prezygopophyses. They possess strong hyposphene articulation which, together with the neural spines, must have greatly reduced the mobility of this part of the vertebral column.

Several incomplete neural spines were recovered, and it is entirely possible that at least some of them belong to the vertebrae just described; but all attempts at actual association have proved disappointing. The same peculiar conditions present in the spines of the cervical vertebrae are here carried to even greater extremes. All are poorly preserved, but one which measures about 300 mm. in length furnishes some idea of the general character of the processes. The exact position which this spine would occupy is, as previously stated, undeterminate; but a comparison of its dimensions with those of the cervicals and anterior caudals suggests that it belongs in the anterior or medial part of the back. It is elongate and massive, very similar, in fact, to the spines of *Altispinax* (*Megalosaurus*) *dunkeri* (Dames) as figured by Owen (1853-1864). Near the base, it is antero-posteriorly constricted, measuring only 76 mm. in that direction. Its fore and aft dimension, however, increases gradually upward, the antero-posterior diameter of the summit being 98 mm. The areas for muscular attachment are extensive and particularly well-developed on the anterior and posterior sides where a rugose, vertical, median lamina separates two narrow but deep lateral grooves.

The dorsals of *Acrocanthosaurus* may be distinguished from those of

Tyrannosaurus, Gorgosaurus, and the other Upper Cretaceous theropods of North America by the more elongate centra and the larger but much more shallow pleurocentral cavities. The well developed hyposphene is absent in *Tyrannosaurus.*

The similarity between *Acrocanthosaurus* and *Antrodemus* is more apparent in the dorsal than in the cervical vertebrae. The relative proportions are practically the same in both genera, but the pleurocentral excavations remain somewhat deeper and the parapophyses relatively shorter in the former genus. It is probable that the anterior dorsals were more strongly opisthocoelous in *Acrocanthosaurus,* still agreeing in that respect with *Megalosaurus* (*Streptospondylus*) *cuvieri* (Owen).

The neural spine is more highly constricted antero-posteriorly and more elongate than in the dorsal vertebra of *Megalosaurus parkeri* figured by von Huene (1926). Although much longer than the dorsal spines of *Antrodemus,* it resembles them in its general construction. Among the Carnosauria, however, the spines of the Oklahoma animal most nearly resemble those of *Altispinax* (*Megalosaurus*) *dunkeri* (Dames) but, as preserved, is relatively shorter than in that form. The general shape of the centra and neural arches is similar in the two animals, but the pleurocentral cavities in the preserved dorsals of *Acrocanthosaurus* are relatively longer and somewhat deeper than in the European form; and the flaring of the articular ends is more pronounced in the former.

The dorsals of *Acrocanthosaurus* are so different from those of *Spinosaurus aegyptiacus* Stromer that no comparison is necessary.

MEASUREMENTS OF THE DORSAL VERTEBRAE (in mm.)

Vertebra	Length of Centrum	Height of Centrum (Posterior End)
1	153	.....
6	107	120
7	110	125
8	.....	126
13	128	136
14	125	137

Caudal Vertebrae.—Three separate series of caudal vertebrae were recovered with the paratype. These constitute the only articulated elements found in either specimen, but the absence of several vertebrae which belong between these segments makes their position within the articulated series somewhat uncertain. Although it is impossible to determine the exact number of elements comprising the tail of *Acrocanthosaurus,* it appears that the number of vertebrae was somewhat greater than in *Antrodemus,* if Gilmore's (1920) estimate of 45 caudals for that genus is correct.

The largest of the fifteen vertebrae represent caudals 1, 2, 3, and 4. It is probable, judging from the degree of taper and the diminution in the height

of the centra, that the next group of four elements belongs in the vicinity of caudals 9 to 12. The more posterior series consisting of seven more or less complete centra and attached neural arches probably should be introduced in the neighborhood of numbers 17 to 23.

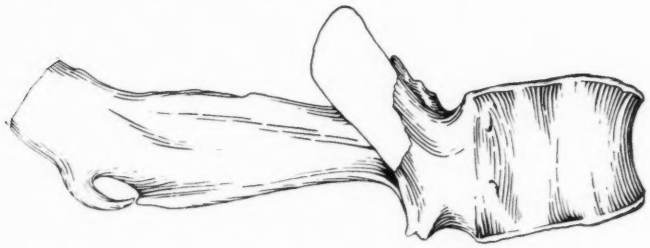

Fig. 4.—Third caudal vertebra of *Acrocanthosaurus atokensis* gen. et sp. nov. 1/6-plus natural size (for exact measurement see page 714).

The centra of the first four caudals are higher than long, but in the more distal elements the height diminishes more rapidly than the length; and, finally, in caudals 9 to 23 the centra are from 12 to 37 millimeters longer than high. The constriction of the lateral and ventral surfaces is less pronounced than in *Antrodemus*, and the resulting flaring of the ends is correspondingly less than in that genus. The pleurocentral excavations are shallow, elongate, and are situated somewhat above the midheight of the centra. The centra of the second and third caudals are gently procoelous and slightly wedge-shaped in lateral aspect, being narrow and wide above. Although the posterior face is very gently convex, the anterior surface is deeply concave. The exact point at which the articulation becomes biconcave is not known, but it is well in advance of the ninth caudal for, in that vertebra, the ends are decidedly concave and subequal in depth. A longitudinal groove, on the ventral surface of the medial caudals is scarcely noticeable on those more anterior in position. The ventral articular lips of all but the first caudal are beveled for the insertion of the chevrons, but there are no true chevron facets.

The neural arches are strongly constructed and almost as long as their respective centra. They are low, and the neural canal is small. The transverse process of the incomplete first caudal is extremely broad and flat. It projects strongly upward and backward and shows every indication of having underlain the ilium, though there was probably no osseous connection between the two elements. The transverse processes of the remaining vertebrae are long and well-developed far back along the tail. They are broad antero-posteriorly, dorso-ventrally flattened, and project strongly outward. The free or outer ends show a strong tendency toward flaring and upward bending. In the anterior caudals, they originate on the sides of the neural arches and project backward at an angle of about 50 degrees. In the more posterior elements, however, their position shifts gradually downward onto the sides of the centra, and the angle between the transverse and longitudinal axes constantly approaches 90

degrees. However, in none of the caudals do the transverse processes appear below midheight on the centrum.

There are only two complete zygopophyses preserved, but from these and several fragments of others, it is evident that the prozygopophyses were somewhat less elongate than in *Antrodemus*. Both anterior and posterior zygopophyses overhung the centra in all of the vertebrae preserved. As in the cervicals and dorsals, the articulation between the caudals was greatly strengthened at the expense of freedom of movement. There is a definite hyposphene-like process projecting downward from the posterior zygopophyses of the first, second and third vertebrae.

The neural spines are elongate but, unlike those of the dorsal series, are flat plate-like processes devoid of heavily sculptured surfaces for the attachment of muscles. In the third caudal, the base of the spine is antero-posteriorly constricted. It broadens gently upward to a point well above midlength where it again decreases somewhat more rapidly in width. The character of the summit is unknown, but at least a slight transverse expansion is indicated. At the widest part of this spine, an ovate foramen pierces the anterior surface of the bone and separates a small downward-projecting finger-like process from the main body of the spine. The progress in the development of this opening in the succeeding vertebrae cannot be observed, but it is assumed to have involved rapid deepening and widening. In caudals 10, 11, and 12, the opening has disappeared; but in its place there is a peculiar step-like development of the anterior edge of the spine. This situation results in the lower part of the spine being nearly twice the width of the upper half. In this region of the tail, the summits of the spines are rounded and expanded antero-posteriorly; but there is very little transverse enlargement. In the remaining series of seven vertebrae, only one spine is preserved. It marks the ultimate in the development of the processes which has been followed throughout the tail. The step-like notch in caudals 10 to 12 has become a wide vertical cleft dividing the spine into two segments, of which the anterior one is much the smaller. The purpose and functions of this small upward projection are unknown. It was at first thought to be the result of a pathological condition; but the construction of the neural arches in the adjacent vertebrae and the general absence of exostosis on the other elements of the skeleton, together with the construction of the other spines in *Acrocanthosaurus*, lead to the conclusion that the development of double spines in these vertebrae represents a normal condition. Evidence further substantiating this assumption has been furnished by Mr. LeRoy Kay (personal communication) who states that in the Carnegie Museum skeleton of *Antrodemus* a similar step-like development is seen in the spine of the sixth caudal and that some type of bifurcation occurs in the eleventh. A similar condition, but developed to a smaller degree, occurs in the caudal vertebrae of *Segisaurus hallii* Camp (Camp, 1936). With the above exceptions, no similar condition is known, although the anterior caudals of *Ceratosaurus nasicornis* do bear some resemblance to caudals 10 to 12 of *Acrocanthosaurus*, a condition which is apparently produced by some pathological condition in the former individual.

The caudal vertebrae of *Acrocanthosaurus* may be distinguished from those

of Upper Cretaceous theropods by the general dimensions of the anterior centra which, in the Trinity animal, are higher than long. A noticeable difference between the caudals of *Antrodemus* and *Megalosaurus* is the smaller degree of constriction of the ventral surface in the anterior elements. The transverse processes were apparently somewhat shorter than in *Megalosaurus* (*Streptospondylus*) *cuvieri* (Owen) and, as in that genus, were present far down the tail. As noted above, there is some similarity between a number of the neural spines of *Acrocanthosaurus* and those of the anterior caudals of *Ceratosaurus nasicornis*. With this notable exception, little agreement can be found, the anterior centra in the latter being longer than high and deeply concave below. The spines of the anterior vertebrae of *Acrocanthosaurus* are, so far as known, unlike those in other theropods; but the spines of *Altispinax* might well exhibit many points of similarity. The spines of *Megalosaurus parkeri* Huene are much shorter and are inclined backward, whereas in the present form they are almost vertical in position.

MEASUREMENTS OF THE CAUDAL VERTEBRAE (in mm.) M.U.O. 8-0-S8

	Length of Centrum	Height of Centrum	Height of Spine	Max. width of Spine	Total Height of Vertebra
1	.....	137	.....	.....	.....
2	128	128*	.....	.....	.....
3	138	170	422*	123	641*
4	140	162	392*	125	558*
9	149	.....	.....	.....	.....
10	146	134	291	89	434
11	141	125	247	84	396
12	140	116	190	95	330
18	.....	105	.....	.....	.....
19	131	103	.....	.....	.....
20	134	97	.....	.....	.....
21	135	94	.....	.....	.....
22	.....	94	142	.....	238
23	124	81	.....	.....	.....

* Measurements of incomplete parts.

Discussion of the Vertebral Spines.—Following the discovery of *Spinosaurus aegyptiacus* Stromer, in 1912, much speculation has centered around the peculiar elongation of the neural spines in the Carnosauria. Stromer (1915) has ably discussed the unique development in *Spinosaurus* but failed to reach a definite conclusion as to its origin or functions. Since the relationship between *Spinosaurus* and *Acrocanthosaurus* is remote, no further allusion to the former genus is necessary, except possibly to note that whatever the functions of the neural spines in the Egyptian animal, they must have differed greatly from those in *Acrocanthosaurus*.

Several other instances of eccentric spinous development may be seen in the ornithopods *Hypacrosaurus altispinus* Brown and *Bactrosaurus johnsoni* Gilmore, as well as in the European theropods *Altispinax dunkeri* (Dames) and *Megalosaurus parkeri* Huene. A further occurrence is reported by Case

in *Coelophysis*, from the Triassic of Texas (Case, 1927). In all of these animals, the neural processes are relatively more elongate than in any of the closely related genera. Apparently in all, the spines were deeply embedded in a thick mass of muscle similar in nature to the high withers in the recent *Bison;* and the animals themselves must necessarily have differed somewhat in appearance from the more "conventional" genera in having a high, thick dorsal ridge. Such a condition is readily adapted to *Acrocanthosaurus*, the spines of which are massive and rugosely sculptured. The suggestions made in connection with the Permian pelycosaurs *Edaphosaurus* and *Dimetrodon* that the spines might have supported a high, fin-like median ridge, or have even been separate spikes in the center of the back, are certainly unacceptable insofar as the present form is concerned.

Environmental adaptation may have played some part in the development of the elongate spines, but the extent of its influence is unknown. It can only be observed in the light of present knowledge that all of the contemporaneous forms from the same horizon and locality apparently exhibit a similar development, and thereby differ from closely allied genera from other parts of the world. The spines of the caudal vertebrae suggest a very high and flat tail which might conceivably have been developed in connection with a semi-aquatic habitat, although the reasons for the adoption of such a habitat by a large and specialized theropod are admittedly obscure.

A mechanical explanation is only little more acceptable than the suggestion of a large theropod with semi-aquatic habits. As mentioned before, the elongation of the spines and the consequent development of strong hyposphene articulation even in the anterior caudals could only have resulted in considerable loss of mobility in the vertebral column. Increased strengthening of the back in support of a massive skull does not appear to be the answer in view of the fact that in *Acrocanthosaurus* the head was proportionately smaller than in *Tyrannosaurus*. In the latter genus, however, the spines are certainly no longer than in the relatively smaller skulled *Antrodemus*.

The question of sexual characteristics necessarily arises whenever peculiar structural development is found in only a few members of a large and well-known group of animals. That sexual differentiation may well present the solution to the problem is readily admitted, but the question, insofar as the dinosaurs are concerned, seems to be of purely an academic nature; and it appears highly improbable that a reliable criterion for sex determination will ever be recognized among these animals.

A partial explanation of the excessive development of the spines may indicate a genetic trend for which no reversal is provided.

Chevrons.—The first chevron was apparently borne between the second and third caudal vertebrae. Of three fragmentary elements recovered only an anterior one from the paratype is sufficiently well preserved to permit critical examination. This bone is similar to its homologue in *Antrodemus* but was less strongly decurved. A small upward projecting spur on the anterior side of each ramus, although present, is not as highly developed as in the *Antrodemus* chevron figured by Gilmore (1920). Such a projection is apparently lacking

in *Megalosaurus*. The two rami are joined proximally by a wedge-shaped transverse bar which protruded slightly between the vertebral centra when articulated. There are no true condyles as are found in the deinodonts. The greatest transverse diameter of the proximal end is 93 mm.

Ribs.—The ribs of both specimens are poorly preserved, the majority being represented only by fragmentary sections of the shafts. Proximal ends of the cervical ribs are unknown, but several more or less complete shafts are preserved. Those from the anterior part of the series are extremely long and slender with a tendency toward a gentle outward and downward bending of the distal portion. The more posterior elements are much shorter, heavier, and more strongly decurved.

No anterior dorsal ribs are recognizable, but several from a more posterior position are fairly well preserved. In each the proximal end is broadly expanded inwardly and extends strongly upward, resulting in the development of an elongate neck which is terminated by a moderately enlarged convex capitulum. The tubercle becomes smaller in each succeeding rib but is still present, though weakly developed, in the last. It is, however, generally poorly differentiated, there being little or no postero-dorsal continuation and only a slight antero-dorsal expansion from the antero-external edge of the shaft. In some of the medial elements, there is a small flange-like process directed upward and outward which joins the antero-dorsal surface of the tubercle.

When viewed laterally, these ribs are noticeably more slender than in *Antrodemus*, although the general contours are similar in the two forms. A short distance below the proximal end, the more anterior ribs are somewhat enlarged, but below this expansion the shafts taper gently downward.

In cross section, the shafts of all but the most posterior ribs are sharply angular proximally due to the presence of deep longitudinal grooves and sharp anterior and posterior continuations of the flat outer surface. At midlength they are subovate to round and finally become antero-posteriorly oval to subround. The only distal termination preserved is slightly enlarged.

Gastralia.—The only abdominal rib preserved is strongly curved, subround in cross section, and greatly enlarged at its inner end where it was overlapped by the next segment. It is composed largely of a highly porous spongiosa, herein differing markedly from the ribs themselves which, like the other bones of the skeleton, are smooth and surficially dense.

The number of elements comprising the abdominal cuirass is unknown; but, in view of other progressive characteristics exhibited by the skeleton of *Acrocanthosaurus*, it might be inferred that there had been some reduction in the total number. Such a supposition is further enhanced by the fact that this particular rib is very similar to those of *Gorgosaurus libratus* Lambe (1917). It is longer and more slender than in *Antrodemus*.

Pectoral Girdle.—Coracoid. The pectoral girdle of *Acrocanthosaurus* is represented by a poorly preserved left coracoid. This bone is higher than wide and somewhat shortened antero-posteriorly with smoothly rounded superior and anterior borders. Inferiorly, there is a broad notch separating the thickly

marginated glenoid fossa and the ventral hook-like extension of the anterior border. A small ovate tuberosity is situated externally a short distance above the apex of this notch and is reflected internally by a deep depression. Outwardly, the coracoid is irregularly convex in all directions, while inwardly it is correspondingly concave. It is thin along the superior and anterior edges but thickens inferiorly and posteriorly towards the glenoid cavity and the scapular surface. It cannot be determined from the present specimen whether the coracoid foramen was entirely enclosed within the coracoid, but it appears that it was situated nearer the coraco-scapular suture than in either *Antrodemus* or *Gorgosaurus*.

Pelvic Girdle.—The pelvis of *Acrocanthosaurus* is represented in the present collection by the incomplete pubes and left ischium from the type and the well preserved pubes of the paratype.

Pubis.—The pubis is similar to that of other large North American carnosaurs but is of relatively more slender proportions. It is altogether unlike the pubes of the more primitive megalosaurs of Europe. In lateral aspect, the shaft is elongate, straight, and slender. It is inclined downward and forward meeting the broadly expanded "foot" at an angle of 35 degrees. When viewed from the front, it is concave inwardly with a medially projecting lamella which is in contact, though not fused, with its mate in the living animal. Some 300 mm. from the distal end these lamelli separate forming an elongate median aperture 160 mm. in length. Below this aperture, the fusion of the distal ends begins posteriorly.

The distal end is expanded antero-posteriorly into the characteristic triangular foot-like termination which in *Acrocanthosaurus* is somewhat narrower vertically than in *Antrodemus*. In the paratype, the pubes are solidly united at the pubic symphysis; but in the type (a younger individual) there is an oval aperture 150 mm. in length along which the two bones are not in contact with one another. From below, the outline of the fused "foot" is similar to that of an isosceles triangle, the short leg being anterior. The rugose inferior surface is flat in all directions with the edges rounded and somewhat transversely expanded.

Ischium.—The preservation of the ischium is of particular interest in that it offers the only evidence concerning the articular relationships of the bones of the pelvis.

The ischium is Y-shaped but differs markedly from that of *Antrodemus* and *Megalosaurus* in its relative proportions, the proximal end being more massive and the shaft more slender than in either of those genera. It is proportionately somewhat more elongate than in the related forms, being nearly, if not quite, as long as the pubis. There is no lateral ridge on the proximal end as in *Megalosaurus parkeri* Huene. The obturator process on the ventro-internal edge is similar in shape and position to that in *Antrodemus*. The articular surface of the expanded pubic process is smooth and marginally rounded, and it is therefore inferred that the pelvic elements were not coossified. In cross section, the shaft is subovate proximally but becomes narrowly oval distally. An elongate tuberosity, more prominent than in *Antrodemus* but

not approaching the angulation seen in *Megalosaurus*, is situated on the supero-external edge of the shaft just below midlength.

The distal end is enlarged, but the degree of the flaring is not determinable from the present specimen.

Hind Limb.—The femora and tibii are incomplete in both specimens, and consequently the relative proportions of the hind limb are somewhat conjectural. The estimations of the length of the separate elements are based on a comparison of the fairly complete fibula and metatarsals with those of other genera to which they bear the closest resemblance. All of the bones of the leg, with the exception of the astragalus, are considerably lightened by the presence of unusually large medullary cavities.

Femur.—The proximal end of the femur is massive with the enlarged, smoothly rounded head directed sharply inward and slightly upward so that its superior surface rises above that of the greater trochanter, with which it is uniformly contiguous. When seen from above, the head and greater trochanter are broadly rounded anteriorly and distinctly concave posteriorly in such a way that the head is somewhat broader than the trochanter in fore and aft direction. The blade-like anterior trochanter extends upward and trends somewhat obliquely from the antero-external edge of the bone downward onto the anterior surface of the shaft. It is strongly developed forward and is separated proximally from the greater trochanter by a broad intertrochantric fossa. Distally, on the anterior edge of this process, there is yet another smaller crestlike tuberosity which projects sharply outward in opposition to the trochanter itself, which has a tendency to bend inward along its anterior edge.

With the exception of a lighter construction probably occasioned by the immaturity of the type, the distal one-fourth of the femur in *Acrocanthosaurus* is very similar to that in *Antrodemus*, but the shaft was apparently less strongly bowed antero-posteriorly in the former genus. The inner and outer condyles are of nearly equal proportions, the tibial condyle being more compressed transversely than in either *Antrodemus* or *Megalosaurus*. Posteriorly, the intercondylar fossa is deep and narrow, whereas on the distal and anterior surfaces it is broad and only slightly concave. The slightly roughened area for the attachment of the femoro-tibialis muscle is a flat, inwardly expanded, longitudinally ovate surface, the angular internal edge of which is continuous with that of the inner condyle. The estimated length of the femur in the paratype is 1153 mm.

Tibia.—The tibia of *Acrocanthosaurus* differs greatly from tibiae of other carnivorous dinosaurs. The angle at the distal articular end, formed by the elongation of the malleolus, is larger than in most of the Jurassic and Cretaceous Carnosauria. The shaft is more strongly bowed outward than in any known allied genus. It is more slender than in *Antrodemus valens* or *Megalosaurus*.

The tibia is slender and moderately expanded transversely at the distal end. When seen from the front, the shaft is bowed strongly outward, the greatest curvature occurring in the lower one-half of the bone, where it is accentuated by the expanding inner malleolus. In lateral aspect, the tibia is gently

curved posteriorly with the upper part bent strongly forward, giving rise to the cnemial crest. The anterior surface is transversely flattened with an elongate, shallow, longitudinal depression along the lower one-half of the bone. The posterior surface is gently rounded transversely and meets the flattened anterior face in a pronounced antero-external angularity. In cross section, the upper part of the shaft is subround, becoming distinctly ovate below and finally, in the distal one-fifth of the bone, changing to a slightly cresentic condition, transversely concave in front and angularly convex behind.

Some 560 mm. above the distal end, the sharp comb-like fibular crest arises abruptly from the antero-external surface of the shaft. Although not completely preserved, it appears probable that this process originally resembled the homologous structure in the Deinodontidae but was apparently somewhat smaller proportionately than in the members of that family.

The distal end is expanded transversely into two arris-like malleoli, of which the external one is decidedly the longer. The shallowly concave area on the anterior face, which was overlain by the ascending process of the astragalus, is broadly triangular in outline and is roughened by numerous longitudinal ridges. A small rugose tuberosity occurs on the anterior side of the external malleolus where the distal end of the fibula was closely applied to the tibia.

Fibula.—The fibula is a very slender, transversely compressed bone. Its lateral surface is smoothly rounded. The upper one-fourth is greatly expanded antero-posteriorly, and the proximal end is broadly triangular in outline. Like the tibia, the shaft of the fibula is strongly curved backward in the center. It is concave inwardly and has a pronounced outward curvature at either end. (Some of the bending may be due to post-mortem distortion.) The fibular process, situated on the anterior edge of the shaft about 285 mm. from the proximal end, is a moderately elongate tuberosity.

The distal end is antero-posteriorly rounded and only slightly enlarged. Its anterior edge is slightly flared, forming a thin flange-like process which overlies the anterior surface of the outer malleolus of the tibia.

Pes.—The poorly preserved astragalus does not lend itself to a detailed discussion; it appears, however, to be similar to that of *Antrodemus*.

The pes in *Acrocanthosaurus* is somewhat more slender than in *Antrodemus*, the third metatarsal being slightly flattened by numbers II and IV. This transverse compaction does not, however, approach the extreme flattened condition of this bone in the deinodonts.

Proximally, the second metatarsal is expanded antero-posteriorly. When seen from above, the shallow concave proximal surface is roughly triangular in outline, with the longest leg of the triangle being applied laterally to number III. The shaft, which is closely applied to that of metatarsal III along three-fourths of the length of the latter, is not as sharply divergent distally as in *Antrodemus*. On the anterior side of the angular left edge of the shaft some 60 mm. from the proximal end, there is a pronounced notch, below which a small sharp-edged, flange-like, tuberosity overlaps the shaft of the third meta-

tarsal. On the posterior side, 180 mm. from the distal end, there is a large triangular pit with sharply raised borders marking the point of contact with the lower part of metatarsal I. The distal end is constricted, the smooth articular surface extending farther up on the posterior than on the anterior side, in sharp contrast to the condition found in metatarsal III. A deep longitudinal notch on the posterior side divides the articular area into two distinct narrow condyles, of which the median or inner one is the smaller.

The flattened proximal end of the third metatarsal, when observed from above, is trapezoidal in outline, the outer longest leg being strongly concave. Proximally, it is concavely expanded antero-posteriorly, but there is no transverse enlargement. Anteriorly, the shaft is flat, bounded laterally by sharp, angular edges. In cross section, it is subtriangular along its entire length, herein differing from the second metatarsal, the cross section of which varies from rectangular above to subround below. An elongate muscle scar occurs on the posterior side 130 mm. from the distal end. The distal end itself is convex antero-posteriorly and concave transversely, resulting in the development of two flat condylar surfaces which are noticeable even on the anterior side. Posteriorly, with the exception of the two small lateral condylar ridges, the bone is only slightly developed.

Distally, both bones exhibit the characteristic lateral pits, of which the external one is in each instance the larger.

The first phalanx of the third digit is a moderately robust bone approximately one-third as long as metatarsal III. It is expanded at both ends and constricted in the center. In lateral aspect, it is bowed slightly upward. The superior surface is gently rounded transversely, while that below is flat to moderately concave. The proximal end is deeply concave vertically and gently concave transversely. Its margin is sharp-edged and slightly higher in the center above than on either side as a result of the presence of a low, rounded, vertical, median keel in the upper one-third of the articular surface. Ventrally, there are two strong longitudinal ridges separated by a broad, sub-triangular, roughened concavity. These lateral ridges disappear at about midlength on the ventral side.

The distal end is pronouncedly convex vertically and moderately concave in the transverse direction. The smooth articular surface is produced farther anteriorly above than below. Just above the superior termination of this surface, a large transverse excavation gives a depressed appearance to the distal one-third of the bone. The two characteristic lateral pits are well developed, the one opposite digit II being subround in outline while the opposite deeper one is roughly triangular.

MEASUREMENTS OF THE HIND LIMB AND FOOT (in mm.)

	Type	Paratype
Femur		
Greatest transverse diameter of proximal end	.....	251
Greatest transverse diameter of distal end	216	.....
Length	1153*	.....

Tibia		
Least transverse diameter of shaft	94	-----
Least antero-posterior diameter of shaft	73	-----
Transverse diameter of distal end	221	245
Length	865*	958*
Fibula		
Width of distal end	58	-----
Width of shaft and midlength	40	-----
Length	801	-----
Metatarsal II		
Transverse diameter of proximal end	63	-----
Transverse diameter of distal end	86	-----
Antero-posterior diameter of proximal end	108	-----
Length	416	-----
Metatarsal III		
Transverse diameter of proximal end	65	-----
Least transverse diameter of shaft	44	-----
Transverse diameter of distal end	100	-----
Antero-posterior diameter of proximal end	125	-----
Length	445	-----
Phalanx III (1)		
Transverse diameter of proximal end	97	-----
Transverse diameter distal end	83	-----
Length	145	-----

* Estimated.

OBSERVATIONS ON THE TAXONOMY OF ALTISPINAX

It is not within the scope of the present study to give a recapitulation of the taxonomic situation with respect to the carnivorous Saurischia; but a brief history of the Wealden genus *Altispinax* is considered desirable inasmuch as certain serious questions may be raised as to the actual composition of the type material representing this very inadequately known form, reference to which has been necessary throughout the present paper.

Dames (1884) described an isolated carnosaur tooth from the lower Wealden of northwestern Germany under the name, *Megalosaurus dunkeri*. Subsequently, Lydekker associated a large number of specimens with *M. dunkeri;* his evidence, however, appears far short of conclusive. Lydekker (1890) described a peculiar metatarsus and identified it with *M. dunkeri* saying:

> Now the type tooth of *M. dunkeri* is of comparatively large size and was obtained from the lower division of the Hastings beds, which must be equivalent either to the Wadhurst Clay or the underlying Ashdowns; . . . The Hollington metatarsus agreeing, therefore, in relative size with the type tooth and coming from approximately the same geologic horizon, there is every probability that it belongs to the same species, to which I accordingly propose to refer it.

The writers cannot accept this association, which was based essentially upon the relative size of two anatomically unrelated elements. It is widely recognized that the relative size of individual and homologous skeletal elements

cannot be employed as a criterion for generic and specific identification in the large saurischian reptiles. The conclusion of Lydekker becomes even more untenable when it is realized that the size of carnosaurian teeth may vary greatly within the dental series of a single individual. In view of the above statement, the correlative geologic horizons seem to be of no great importance in the present instance inasmuch as the two locations are widely separated.

Von Huene (1926), however, apparently considers such an association as valid. He states:

> Bones referred to this species by Lydekker are not rare. . . . If No. 74 (three articulated medial dorsal vertebrae with extremely high neural processes) as seems to be the case—also belongs here, the species possesses enormously high neural spines in the dorsal vertebrae corresponding to four vertebral lengths. . . . But here, in fact, it is very remarkable for a carnosaurian and if it were confirmed that such dorsal vertebrae indeed belong to *Megalosaurus dunkeri* it would be necessary to put it into an own genus for which the name *Altispinax* n. gen. could be reserved.

Von Huene then concludes:

> The skeletal remains according to Lydekker, belonging with the teeth of *Megalosaurus dunkeri* (Dames) from the Lower Wealden are so different from *Megalosaurus* that they do not fit into the genus. Dorsal vertebrae with very high neural processes apparently belong together with these, and on this assumption the genus is called *Altispinax*. Probably the species *Oweni* (Lydekker) from the Upper Wealden belongs also there.

Von Huene is nowhere explicit as to just which material he considers the type of the genus *Altispinax*, nor does he state whether the various specimens referred to that genus were found in sufficient proximity to render their actual association acceptable. From the various statements concerning the material, however, it appears to the writers that the specimens which have been incorporated in the type material were, for the most part, found at different times and in more or less widely separated localities and that very little association actually existed between them. Furthermore, it is not clear how much duplication of the individual elements has occurred. Consequently, when von Huene states that "Dorsal vertebrae with very high neural processes apparently belong together with these and on this assumption the genus is called *Altispinax*," apparently the vertebrae under consideration should be considered as constituting the type; and the association of other elements with them should be considered as problematical until such time as later discoveries may prove the validity of the association.

For the above reasons, therefore, allusion to other bones of *Altispinax* has been avoided in the present paper.

THE RELATIONSHIPS OF ACROCANTHOSAURUS

The carnosaurian affinity of *Acrocanthosaurus atokensis* is manifest in every known element of the skeleton. The problem of family relationship, however, has been greatly complicated from the very outset of the present study because of the inadequacy of comparative material. Although a considerable portion of the skeleton is known and a reasonably clear conception of the osteology can be gained from these remains, the more important details of structure from the taxonomic viewpoint have not been preserved.

During the past fifty years, certain definite conclusions have been reached concerning criteria of family importance among the Carnosauria. Comparison with these various criteria has been somewhat limited insofar as much of the present material is not of diagnostic value.

Acrocanthosaurus is excluded from the Deinodontidae by the relative elongation and pronounced opisthocoelous character of the cervical and anterior dorsal vertebrae, the relatively heavier construction of the pelvic elements, and the subequal proportions of the metatarsals in that genus.

The pronounced opisthocoelous character and great elongation of the dorsal vertebrae, together with the peculiar costal articulation in *Spinosaurus aegyptiacus* Stromer, remain unique among the large carnivorous saurischians. Consequently, the slight resemblance of the present form to the Spinosauridae, occasioned by the tendency toward elongation of the neural spines, is considered unimportant.

Comparison with the Megalosauridae of Europe and the Antrodemidae of North America has proved especially difficult owing to the similarity of the two groups. The association of *Acrocanthosaurus* with either of these families if, in fact, two separate families do exist, must be considered problematical since that genus presents many features common to both.

Certain characteristics of the Antrodemidae, however, find the closest analogy in the present form and differ accordingly from those exhibited by the European group. Principal among these are the construction of the skull, the general proportions of the vertebrae, and the broadly expanded pubic "foot,"* the straight elongate shaft of the ischium, and the presence of an anterior upward projection in the anterior chevrons. These features, together with the geographic consideration, seem sufficiently important at present to justify the incorporation of *Acrocanthosaurus* into the family Antrodemidae.

The peculiar development of the neural spines is apparently of little systematic importance and *Acrocanthosaurus* may be considered an example of parallel development along the lines indicated by *Megalosaurus parkeri* and *Altispinax*.

CONCLUSIONS

1. The present form, described under the name of *Acrocanthosaurus atokensis* in allusion to the elongate neural spines, represents a large and aberrant carnivorous saurischian at present peculiar to the Trinity Cretaceous of Atoka County, Oklahoma.

2. The genus, as here described, clearly falls within the range of the forms encompassed by the Carnosauria but is generically and specifically distant from all known members of that group.

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* The presence or absence of the broadly expanded pubic symphysis in the true megalosaurs has not been definitely ascertained, but presently known specimens apparently lack any such enlargement. *Megalosaurus parkeri* does, however, exhibit some enlargement, but does not approach the extreme condition seen in *Antrodemus* or the later deinodonts.

3. Family affinities are not clear, but on the basis of arguments of geologic and geographic distribution, the genus has been incorporated into the Family Antrodemidae Marsh.

4. Massive and elongate neural spines, which are apparently characteristic of the genus, are considered as a rapidly acquired characteristic. Such spines were imbedded in a thick and high dorsal ridge of muscle, but the reasons for such development are obscure.

5. The validity of certain European material ascribed to *Megalosaurus dunkeri* Dames is questionable.

6. *Altispanax dunkeri* (Dames) is a valid form only when the type material is understood to include only the three dorsal vertebrae described by Owen as *Megalosaurus bucklandi* Meyer.

7. *Acrocanthosaurus atokensis* is considered as a case of parallel development along the lines indicated by the older European forms *Megalosaurus parkeri* Huene and *Altispinax dunkeri* (Dames), and the latter are not necessarily ancestral to it.

ACKNOWLEDGEMENTS

The writers wish to express their thanks to Mr. John S. McIntosh, of Yale University and Dr. W. E. Swinton, of the British Museum (Natural History), the former for his interest in the problem and his comments in connection with his personal observations of related material in various North American museums, and the latter for furnishing important references concerning European theropods. Mr. LeRoy Kay, of the Carnegie Museum, and Dr. Hyrum Schneider, of the University of Utah, have obligingly furnished photographs of important theropod material in their respective institutions.

Thanks are also due to Messrs. Herman Arnold and W. P. Cochran for permission to dig on their land; to Mr. James H. Bragg of the University of Oklahoma Photographic Services for the photography; to Mr. Ralph B. Shead, W.P.A. Supervisor, for records; to Mr. Joe Southern for reporting the discovery; to various W.P.A. workers for excavation and preparation of the fossils; and to Mr. Tom Wilson for preparing culture and drainage maps of most of the sections in the township and for reporting additional discoveries.

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Plate 1.—*Acrocanthosaurus atokensis* gen. et sp. nov. Cranium. M.U.O. 8-O-S9. Front view. Fr—frontal, Pa—parietal, Poc—paroccipital process, Prot—prootic, Bsp—basispenoid, Bpt—basipterygoid process of the basisphenoid, Pas-parasphenoid, Psp?—supposed presphenoid, Eth?—supposed ethmoid, F.O.—fenestra ovalis, C.I.—entrance of internal carotid, Pi Fos—pituitary fossa, I-V—exits of cranial nerves i-v. About two-fifths natural size.

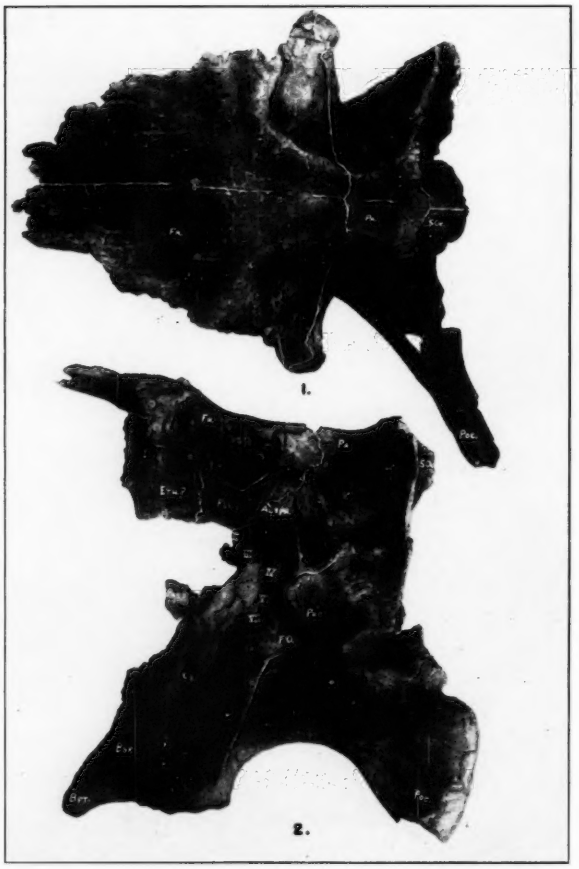

Plate 2 . Figs. 1, 2. *Acrocanthosaurus atokensis* gen. et sp. nov. Cranium. M. U. O. 8 O-S9.—1. Superior view; Fr—frontal, Pa—parietal, Soc—supraoccipital, Poc—paroccipital process; 2. Lateral view; Prot—prootic, Psp?—supposed presphenoid, Eth?—supposed ethmoid, Bsp—basisphenoid, Bpt—basipterygoid process of the basisphenoid, Pas—parasphenoid, F.O.—fenestra ovalis, C.I.—lower entrance of internal carotid, I-VII—exits of cranial nerves i-vii. Both figures about two-fifths natural size.

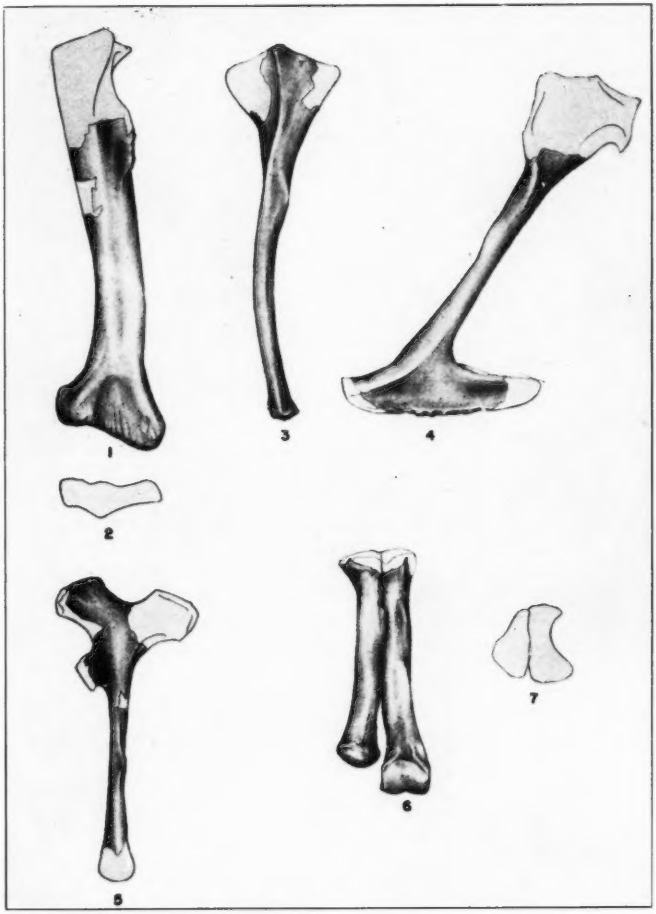

Plate 3. Figs. 1-7. *Acrocanthosaurus atokensis* gen. et sp. nov.—1. Left tibia, M. U. O. 8-O-S9. Anterior view; 2. Outline of distal end of left tibia, M. U. O. 8-O-S9; 3. Right fibula, M. U. O. 8-O-S9. Lateral view; 4. Left pubis, M. U. O. 8-O-S8. Lateral view; 5. Left ischium, M. U. O. 8-O-S8. Lateral view; 6. Left metatarsals II and III, M. U. O. 8-O-S8. Anterior view; 7. Outline of proximal articular surfaces of metatarsals II and III, M. U. O. 8-O-S8. All figures about one-tenth natural size.

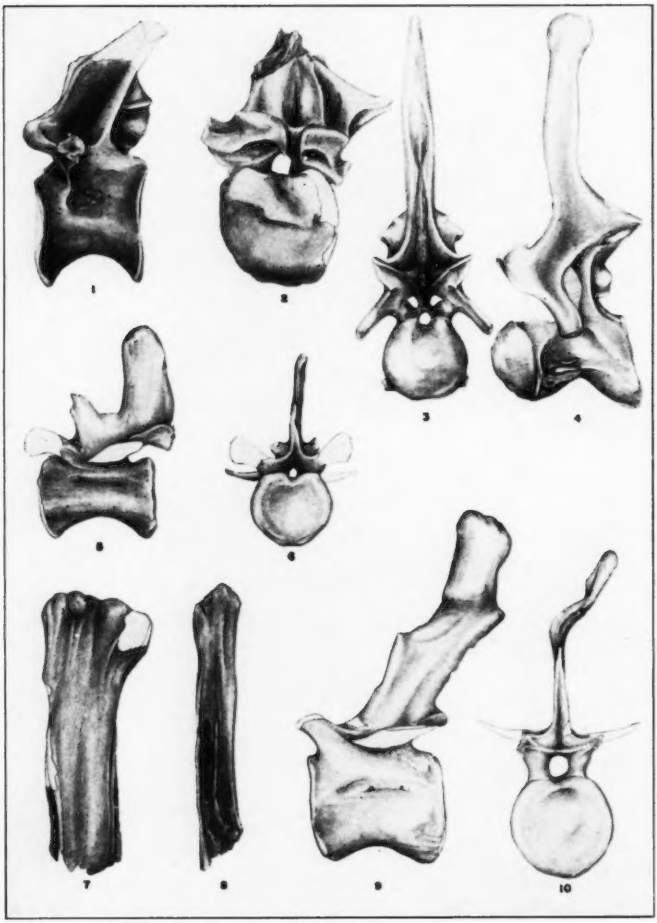

Plate 4. Figs. 1-10. *Acroconthosaurus atokensis* gen. et sp. nov. Vertebrae.—1. Sixth dorsal, M. U. O. 8-O-S9. Lateral view; 2. Same. Anterior view; 3. Ninth cervical, M. U. O. 8-O-S9. Anterior view; 4. Same. Lateral view; 5. Medial caudal, M. U. O. 8-O-S8. Lateral view; 6. Same. Anterior view; 7. Dorsal spine, M. U. O. 8-O-S9. Lateral view; 8. Same. Anterior view; 9. Eleventh caudal, M. U. O. 8-O-S8. Lateral view; 10. Same. Anterior view. All figures about one-eighth natural size.

Forest Types in the Versailles State Park Area, Indiana*

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Indiana is a very sensitively balanced climatic region where comparatively small differences in soil moisture induce striking differences in forest cover types. The author has pointed this out repeatedly for the rugged section of Indiana. Climatic climax is no doubt the mixed mesophytic forest in which beech and sugar maple are the most important members. Associated with them, however, in minor importance, at least by way of abundance and frequency index, are up to twenty additional species of trees. Included in the association are usually some of the more mesophytic oaks (*Quercus muhlenbergii, Q. borealis* var. *maxima*), and at times even *Quercus alba. Ulmus fulva* and *Aesculus glabra,* whose characteristic habitat is in more moist lowland situations, are also frequent associates.

This somewhat heterogeneous association dominates habitats where mesophytic conditions are found at their best, i.e. on well-drained flat areas and on north-facing slopes of moderate steepness.

The climax forest association complex is induced to separate by small changes in the mesophytic conditions, and new association complexes develop with such changes. In the two diverging extremes beech and sugar maple do not appear as associates. Sugar maple (*Acer saccharum*) continues as dominant with mesophytic oaks, ash, and hickories in habitats representing increasing dryness (Tables 1, 8, 9) while beech (*Fagus grandifolia*) extends its range into wet, poorly drained "flats" habitats where sugar maple does not ecese. This unique Illinoian tillplain habitat forest association has been described by Braun (1936), McCoy (1939), Keller (1946), and others. All of these major and minor variations in forest association may be observed in the Versailles State Park (Laughery Creek valley) area in Ripley County as slope exposure varies, or as one moves from well-drained to poorly drained habitats (Tables 1-9).

Methods

Scientific names of plants are those of Deam's *Flora of Indiana,* except for the spice bush (*Lindera benzoin*) and cork elm (*Ulmus thomasi*) which are considered valid recent changes in nomenclature.

The sampling unit was a 100-square-meter quadrat. A stout cord with loops at 10-meter intervals, rolled on a reel, permitted easy delimiting of each sampling unit. All stems one inch or over DBH. were measured with a wooden caliper. All stems of less diameter dimensions, but being at least three feet

* This is publication 1 of the faculty of the Conservation Education Camp at Versailles State Park, and publication 214 of the Botany Laboratory of Butler University.

in height, were tabulated. This latter size-class was intended to serve as indicator of reproduction in the stands. The field work shown in tables 1, 2, 3, 4 was carried out by members of the conservation class of 1948 under the supervision of professors Howard H. Michaud, T. E. Shaw of Purdue University, and the writer. Data for table 6 were collected by the writer and Leland Chandler of Friendship, Indiana, who was also a member of the class of 1948. Since the confines of Versailles State Park did not offer good north-facing slopes, data for tables 5 and 8 were collected in the Edwin C. Droge woods, two miles east of Friendship in Dearborn County, and those for table 9 were collected on the farm of Mr. Fred Harting, one mile east of Dewberry in Ohio County. All stands were, however, located in or near the valley of Laughery Creek. For lack of an undisturbed stand of the Illinoian Tillplain type forest in the Versailles Park region, data of the ecological survey of Klein woods in Jennings County by C. O. Keller (1946) are given as table 7, to be compared with a disturbed stand in Versailles Park (Table 4).

The Versailles Park region has been severely lumbered in the past and so the stands of forest are not only small in area but also at best mostly in progress of late Secondary succession. An exception is the stand of climax forest (Table 2) in the southeastern part of the Park.

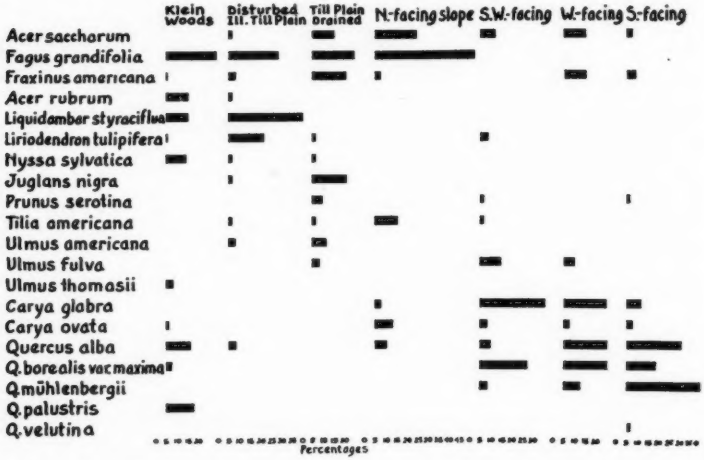

Fig. 1.—Percentage of total stems 6 inches or over DBH. which a given species has in a given habitat site. Showing importance of different species in the crown cover.

In order to stress the importance of certain tree species in control of crown cover, all stems which measured at least 6-inches DBH. were figured for percentage of total number of stems tabulated in a given stand. The percentages are plotted in a graph as Figure 1. This accentuates association complexes but also shows changes in associated species as one progresses from moist to dry slope or from drained to undrained Illinoian Tillplain habitats.

In the nine tables shrubs are not listed interspersed with the trees but appear as separate group following the list of trees.

OBSERVATION

Results of the observations are perhaps best presented by the summary tables themselves (Tables 1-9), and the graph (Fig. 1). There are first of all the two habitat sites with the climax forest cover type (mixed mesophytic) where beech and sugar maple are the most important components, as judged from crown cover control, abundance, and frequency (Tables 2 and 5, Fig. 1). One of these is located on moderately steep north-facing slopes (Table 5) and the other is found on better drained flat tillplain area (Table 2). As referred to in the introduction, the two most important species in the climax forest respond very differently to modifications of the optimum mesophytic conditions. Beech continues as co-dominant in new associations on the poorly drained, insufficiently aerated Illinoian Tillplain habitats. It is associated there with sweet gum (*Liquidambar styraciflua*), red maple (*Acer rubrum*) sour gum (*Nyssa sylvatica*) and several species of oaks and hickories (Tables 4, 7), while sugar maple does not extend into this habitat at all Sugar maple has, on the other hand, the potentiality to endure the habitats with less soil moisture as one moves with the compass to the xerophytic south-facing slopes. It is, however, plainly evident that south-facing slopes mark the limit of decreased soil moisture which sugar maple requires for successful ecesis (Table 6). Reproduction by sugar maple is amazingly prolific in all habitats except in the typical "flats" type, so that one wonders why it is not more abundant at maturity in the various habitats, including even that of south-facing slopes.

DISCUSSION

The range of potentiality of tree species to endure highly varying habitat conditions presents one of the most fascinating phenomena for the ecologist. No doubt a complex of factors is involved, which may never be well understood. In Indiana one recognizes a wide potentiality in this respect in white oak (*Quercus alba*), sugar maple, beech, ash (*Fraxinus americana* and *F. lanceolata*), and to a lesser degree shagbark hickory (*Carya ovata*). In the Laughery Creek region white oak and ash show the widest range in potentiality to endure varying edaphic factors. They participate in crown control of the unique "flats" forest type (Tables 4, 7), they are co-dominants in the climatic climax forest on moderately steep north-facing slopes (Table 5), and they maintain high abundance in the most xeric habitats on south-facing slopes (Table 6). In Versailles Park (Laughery Creek valley) *Quercus muhlenbergii* (Chinquapin) even surpasses *Q. alba* in abundance and per cent frequency. This abundance of *Q. muhlenbergii* on south-facing slopes is to the writer's knowledge a characteristic feature of such slopes in Illinoian Tillplain areas. Besides the present report from Ripley, Ohio, and Dearborn counties, Potzger and Friesner (1940) cite a similar behavior of this oak in a survey in Franklin County.

Sugar maple and beech present a most fascinating association range. In mesophytic habitats the two species share importance in crown control, how-

ever, sugar maple holds this place in the association only by aid of prodigious reproduction, as Tables 2 and 5 plainly show. One never ceases wondering how beech can compare with sugar maple at maturity when beech reproduction as a rule appears to be so inadequate and limited. The only places where the author saw aggressive reproduction by beech was on Mackinac Island, Michigan (1941) and in the Klein woods (Table 7), Jennings County, Indiana. Rübel (1930) commented on this same characteristic of the two leading contenders for crown control in the climax forest of Michigan. He expressed the opinion that beech may very likely reach maturity if it survives competition during the first two years of growth. In a private communication Professor Daniel DenUyl of Purdue University describes a high reproduction rate by beech on the Moses Fell Annex Farm, Purdue University Agr. Exp. Sta., Bedford, Indiana.

The characteristic climax forest control on north-facing slopes in unglaciated southern Indiana has been investigated by Potzger (1935), and by Potzger and Friesner (1940). In a succeeding study of aerial and edaphic factors prevailing on south and north-facing slopes, Potzger (1939) found that south-facing slopes not only had 60 per cent greater loss of water by evaporation during a summer but that soil moisture dropped below the w. c. for most weeks while the study was in progress. In a more extensive study Friesner and Potzger (1937) found that more xeric conditions prevailed in habitats characterized by oak-hickory associations than in those characterized by mixed mesophytic forests. These same workers (1940) found that there was also a striking difference in the composition of the herbaceous flora beneath the crown cover of these two forest types. In the Versailles Park area variety is added to habitat sites by the unique, geographically limited Illinoian Till-plain. It is marked by severely leached and poorly drained soil. Oddly enough, this habitat is open to beech but constitutes a barrier to ecesis by sugar maple. One is always impressed with the comparatively small physiographic changes which may induce striking change in forest type. A few feet of cut by a small stream, with better drainage of the adjoining tillplain habitat eliminates the beech-sweet gum-red maple-sour gum association, selects beech as a co-dominant with sugar maple in a new mixed mesophytic association (Table 2). Change in slope exposure is marked by changes in forest cover which are just as striking as in the tillplain modification just described. In the Droge woods a meandering small stream has produced a varied pattern of slope exposure, giving rise to an accompanying heterogeneous forest cover in a comparatively small areal extent. Table 5 presents tabulations of forest composition on gentle north-facing slopes. Table 8 shows forest composition on a west-facing slope. These two merged into one another so imperceptibly that change in exposure of slope had escaped our attention as we progressed in the quadrat work. Change in forest cover, however, very forcefully indicated the change in this physiographic feature of the habitat. Potzger (1935) discussed such culminating change in forest type when north- and south-facing slopes in unglaciated Indiana are compared. The cause of these changes is apparently soil moisture, for in Laughery Creek valley steep, rocky north-facing slopes (favoring excessive run-off) may be covered by an oak-hickory forest type (Table 9) in which sugar maple persists as co-dominant. Here, again, the maple dis-

plays the potentiality to invade and ecese in habitats which are too dry for beech. As previously referred to, Versailles State Park confines and Laughery Creek valley in general, present such a variety of habitat sites that forest cover seems very mobile, and so the region offers splendid opportunity to the ecologist to observe that an association is, indeed, bound by a very loose tie when climate permits invasion by many species of trees which differ somewhat in their habitat requirements. This makes possible a wide range of association complexes. There results then the fascinating feature of facets of slope exposure which involves amount of soil water conserved against runoff or evaporation losses, and on the other hand accumulation of water where runoff is checked. Both habitat conditions find expression in their own forest cover type which usually has as component one of the two most prominent climax forest species. When, however, optimum mesophytic conditions prevail, beech and sugar maple meet in an association which to all appearances is climatic climax for the Laughery Creek valley region as well as for Indiana in general.

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TABLE 1.—Tabulation of woody species from twenty 10-meter-square quadrats on gentle south-west slope. Stand located directly east of camp.

Species	Number of stems in seven diameter classes (inches)								
	Below 1 in.	1-2	3-5	6-10	11-15	16-20	Above 20	Total stems	% F. I.
Acer negundo	32	13	3	1				49	80
Acer saccharum	166	120	58	4				348	100
Aesculus glabra	1							1	5
Carya cordiformis			11	12	6			29	70
Carya glabra	1	2		1				4	15
Carya ovata	2	3						5	15
Celtis occidentalis			1					1	5
Cercis canadensis		1						1	5
Cornus florida		1	2					3	15
Fraxinus americana	8		1					9	25
Fraxinus lanceolata	1		6	2				9	25
Fraxinus pennsylvanica	1							1	5
Fraxinus quadrangulata	48	1						49	60
Gleditsia triacanthos					1			1	5
Liriodendron tulipifera				1	1			2	5
Morus rubra	2							2	10
Nyssa sylvatica	2		2					4	15
Ostrya virginiana	1							1	5
Prunus serotina					1			1	5
Ptelea trifoliata	3							3	5
Quercus alba			1	2			1	4	10
Quercus borealis var. maxima			2	3	6	3	1	15	35
Quercus muhlenbergii	3	4	9		1	1		18	60
Sassafras albidum		2			1			3	15
Tilia americana	1					1		2	5
Ulmus americana			3	2				5	15
Ulmus fulva	8		1	4		2		15	40
Viburnum acerifolium	1							1	5
Viburnum prunifolium	3							3	10
Vitis sp.?	19	13						32	65

TABLE 2.—Tabulations of woody species from thirty-three 10-meter-square quadrats on well-drained Tipton Tillplain soil in the southeastern section of Versailles State Park.

Species	Number of stems in seven diameter classes (inches)								
	Below 1 in.	1-2	3-5	6-10	11-15	16-20	Over 20	Total stems	% F. I.
Acer nigrum	2	1	2		1	1		7	9
Acer negundo	1							1	3
Acer saccharum	667	263	58	3	1		6	998	100
Aesculus glabra	1	2	1					4	9
Carpinus caroliniana		4						4	12
Carya cordiformis	7							7	3
Carya glabra	13	3	1					17	3
Carya ovata	2		1					3	9
Celtis occidentalis	12	1	1	1			1	16	33
Cornus florida	59	38	16	2				115	54
Fagus grandifolia	5				2	1	8	16	36
Fraxinus lanceolata	35	15	9	7	2			66	72
Fraxinus pennsylvanica	1							1	3
Fraxinus quadrangulata	12	7		1				20	30
Juglans nigra				1	6	1	1	9	15
Liriodendron tulipifera							1	1	3
Morus rubra	27	4	1					32	51
Nyssa sylvatica	6	7	4	1				18	24
Ostrya virginiana	26	3	9	4				42	33
Prunus serotina	21	5	5	2	1			34	48
Quercus alba	1							1	3
Quercus borealis var. maxima	3	1						4	15
Quercus muhlenbergii	1							1	3
Sassafras albidum	2	5						7	3
Tilia americana	2	2			1			5	6
Ulmus americana	19	5	3	4				31	45
Ulmus fulva	72	8	5	1	1			88	42
Asimina triloba	31							31	15
Celastrus scandens	5							5	9
Evonymus atropurpureus	9							9	3
Lindera benzoin	32							32	27
Parthenocissus quinquefolia	564	2						566	33
Rhus radicans	61							61	15
Ribes sp.?								27	33
Sambucus canadensis	5							5	6
Smilax glauca	17							17	15
Viburnum acerifolium	83							83	24
Viburnum prunifolium	1							1	3
Vitis sp.?	16							16	21

TABLE 3.—Tabulations of woody species from twenty 10-meter-square quadrats in a young stand of the "Flats" woods type, near the fire tower road.

Species	Number of stems in diameter classes (inches) Below 1 in.	1-2	3-5	6-10	Total stems	% F. I.
Acer rubrum	261	148	4	1	414	100
Acer saccharum	2				2	5
Carpinus caroliniana	1				1	5
Fagus grandifolia	1				1	5
Fraxinus americana	18	1			19	50
Fraxinus pennsylvanica	1				1	5
Juniperus virginiana	4				4	15
Liquidambar styraciflua	138	246	45		429	100
Liriodendron tulipifera	38	2	1		41	45
Nyssa sylvatica	3	1			4	20
Platanus occidentalis	8	3	1		12	15
Populus grandidentata	8				8	20
Prunus serotina	8	2			10	15
Quercus alba	1	1			2	10
Quercus palustris	8	1			9	10
Robinia pseudo-acacia	4				4	5
Sassafras albidum	3				3	15
Salix sp.?	31				31	20
Ulmus americana	15	1			16	30
Campsis radicans	489				489	60
Lindera benzoin	1				1	5
Rhus glabra	45				45	15
Rhus radicans	11				11	15
Rubus allegheniensis	9				9	15
Vitis sp.?	37				37	40

TABLE 4.—Tabulations from eighteen 10-meter-square quadrats in old stand beech-sweet gum-red maple woods. Southeastern part of Versailles Park.

Species	Number of stems in seven diameter classes (inches)								
	Below 1 in.	1-2	3-5	6-10	11-15	16-20	Over 20	Total stems	% F. I.
Acer rubrum	20	10	5	1				36	33
Acer saccharum	31	4	2		1			38	83
Carpinus caroliniana	31	20	4					55	38.5
Carya glabra	12	5	2					19	38.5
Carya ovata	1							1	5.5
Celtis occidentalis	3							3	6.5
Cornus florida	32	25	7					64	77
Crataegus sp.?	1							1	5.5
Fagus grandifolia	15	7	2	3	2	1	8	38	88
Fraxinus americana	86	29	4	2				121	88
Fraxinus pennsylvanica	5							5	5.5
Fraxinus sp.?	2	2						4	5.5
Juglans nigra						1		1	5.5
Juniperus virginiana	6							6	17
Liquidambar styraciflua	37	17	15	20	1			90	60
Liriodendron tulipifera	10	22	12	8	1		1	54	55
Morus rubra	2	3	2	1				8	33
Nyssa sylvatica	12	8	3					23	38
Ostrya virginiana	2							2	11
Platanus occidentalis			1	1	1			3	17
Populus grandidentata	1							1	5.5
Prunus serotina	7	2	1					10	22
Quercus alba	3	4	3	1	1			12	27
Quercus borealis var. maxima	5	2						7	17
Sassafras albidum	21	4	1	1				27	49
Tilia americana	1					1		2	11
Ulmus americana	21	15	6	2				44	60
Ulmus fulva	5							5	22
Aralia spinosa	45	4	1					50	38
Asimina triloba	10	1						11	11
Evonymus atropurpureus	1							1	5.5
Lindera benzoin	3							3	11
Parthenocissus quinquefolia	51							51	11
Rhus glabra	10	14						24	11
Rhus radicans	11							11	22
Ribes sp.?	15							15	5.5
Rosa sp.?	7							7	11
Campsis radicans	31							31	11
Smilax glauca	10							10	5.5
Vitis sp.?	17							17	27

TABLE 5.—Tabulations of woody species from fifteen 10-meter-square quadrate on North-facing slopes in the Droge woods.

Species	Number of stems in seven diameter classes (inches)								
	Below 1 in.	1-2	3-5	6-10	11-15	16-20	Above 20	Total stems	% F. I.
Acer saccharum	91	56	26	4		1	2	190	100
Aesculus glabra	1							1	7
Carya cordiformis	1			1				2	13
Carya glabra		2	2	1				5	13
Carya ovata	4	1	2	3				10	20
Cornus florida	8	10	3					21	47
Fagus grandifolia	18	1	1	1	4	9	3	37	93
Fraxinus americana	24	3	1			1		29	53
Fraxinus quadrangulata	19	1						20	27
Juglans nigra	1							1	7
Juniperus virginiana	1							1	7
Morus rubra	41	1						42	27
Ostrya virginiana	43	11	3					57	87
Prunus serotina		1						1	7
Quercus alba	22	2	1	1	1			27	47
Tilia americana				2	2			4	13
Ulmus americana			1					1	7
Ulmus fulva	22	13	1					36	40
Asimina triloba	14							14	13
Lindera benzoin	4	1						5	20
Ribes sp.?	9							9	40
Smilax glauca	21							21	20
Viburnum acerifolium	8							8	7
Viburnum prunifolium	1	1						2	7
Vitis sp.?	3							3	13

TABLE 6.—Tabulation from 20 ten-meter-square quadrats on south-facing slope in Versailles State Park.

Species	Number of stems in seven diameter classes (inches)								
	Below 1 in.	1-2	3-5	6-10	11-15	16-20	Above 20	Total stems	% F. I.
Acer saccharum	301	123	4	1		1		430	100
Aesculus glabra	4	10						14	40
Carpinus caroliniana	6	1						7	15
Carya cordiformis	3		1					4	20
Carya glabra	12	9	5	5				31	45
Carya ovata	9	8	2	2				21	55
Cercis canadensis	46	20	1					67	60
Cornus florida	8	2						10	30
Crataegus sp.?	12	1						13	30
Fraxinus lanceolata	101	17	7		2		1	128	90
Fraxinus quadrangulata	19							19	60
Gleditsia triacanthos	1							1	5
Juniperus virginiana	4	3						7	20
Ostrya virginiana	108	38	4					150	100
Prunus serotina	2			1				3	10
Quercus alba	12	36	7	1	9	8	1	74	60
Quercus borealis var. maxima	15	5		2	5	3		30	60
Quercus muhlenbergii	45	45	12	19	7	1	3	132	100
Quercus velutina						1		1	5
Celastrus scandens	76							76	35
Evonymus atropurpureus	2							2	10
Ptelea trifoliata	3							3	10
Ribes sp.?	4							4	5
Rhus radicans	14	4						18	35
Rhus glabra		1						1	5
Smilax glauca	7							7	5

TABLE 7.—Tabulations of woody species from fifty 10-meter-square quadrats in the Klein woods (flats type), Jennings County, Indiana.

Species	Number of stems in seven diameter classes (inches)								
	Below 1 in.	1-2	3-5	6-10	11-15	16-20	Above 20	Total stems	% F. I.
Acer rubrum	224	32	8	12	4	2	1	283	76
Carpinus caroliniana	2	2	1					5	8
Carya laciniosa	12							12	16
Carya ovata	19		3	1			1	24	30
Cornus florida	37	5	1					43	22
Fagus grandifolia	500	90	3	3	18	16	5	635	98
Fraxinus americana	227	2			1			230	70
Fraxinus biltmoreana	1							1	2
Liquidambar styraciflua	51	3	1	17	12	3	1	88	70
Liriodendron tulipifera	23	2	2				1	27	30
Morus rubra	3							3	6
Nyssa sylvatica	78	39	33	14		1	2	167	74
Ostrya virginiana	2							2	4
Prunus serotina	46	10						56	48
Quercus alba	6	1		2	4	5	9	27	38
Q. borealis var. maxima	1				1	3	1	6	8
Q. palustris	1				4	5	14	24	38
Q. prinus	9	1			1		1	12	14
Sassafras albidum	54	4		1	1	1		61	54
Ulmus thomasi	145	14	8	5	1			173	56
Asimina triloba	2							2	2
Celastrus scandens	3							3	2
Lindera benzoin	63							63	24
Rhus radicans	388							388	54
Ribes sp.?	24							24	4
Rubus occidentalis	38							38	6
Sambucus canadensis	18							18	16
Smilax hispida	1							1	2
Smilax rotundifolia	569							569	80
Vitis sp.?	7							7	8

TABLE 8.—Tabulations of woody species from ten 10-meter-square quadrats on a west-facing slope in the Droge woods.

Species	Number of stems in seven diameter classes (inches)								
	Below 1 in.	1-2	3-5	6-10	11-15	16-20	Above 20	Total stems	% F. I.
Acer saccharum	4	37	20	2	2			65	100
Carya cordiformis					1			1	10
Carya glabra		1	6	8				15	50
Carya ovata			7	1				8	30
Celtis occidentalis		1						1	10
Fraxinus americana		3	2	2	2			9	50
Fraxinus quadrangulata		2						2	20
Ostrya virginiana		3	4					7	50
Quercus alba	2		2	5	2	1		12	40
Quercus borealis var. maxima			2	2		2	4	10	40
Quercus muhlenbergii				2	1			3	20
Ulmus fulva	1			2				3	10
Dirca palustris	4							4	10
Ribes sp.?	11							11	10

TABLE 9.—Tabulations of woody species from ten 10-meter-square quadrats on steep, rocky north-facing slope on the Harting farm.

Species	Number of stems in seven diameter classes (inches)								
	Below 1 in.	1-2	3-5	6-10	11-15	16-20	Above 20	Total stems	% F. I.
Acer saccharum	12	44	34	9	3	1		103	100
Aesculus glabra	1	4		2				7	50
Carpinus caroliniana		2						2	10
Carya glabra	1	2	1					4	30
Carya ovata	1	1	3	1	2			8	40
Cercis canadensis	4							4	30
Cornus florida	4							4	20
Fraxinus americana	30	2	1	1	2			36	90
Fraxinus quadrangulata	31	2						33	90
Juglans nigra					1			1	10
Ostrya virginiana	93	6	4					103	100
Quercus borealis var. maxima		2	2	2	3	1	2	12	60
Q. muhlenbergii	8	1	3	2	1	2	1	18	70
Aralia spinosa	1							1	10
Celastrus scandens	11							11	20
Dirca palustris	19							19	50
Rhus radicans	6							6	30
Ribes sp.?	25							25	40
Smilax hispida	1							1	10
Viburnum prunifolium	12							12	40
Vitis sp.?	1							1	10

Preliminary Reports on the Flora of Georgia. 2. Distribution of 87 Trees.

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Detailed information on the distribution of trees in Georgia is of greater significance than in most states because Georgia is at a key location geographically. Many species of generally northern distribution have their most southeastern locality in the state, and many species of generally southern distribution begin their swing up the eastern seaboard in Georgia. In order to get a clearer distributional picture of each species in Georgia and consequently for its entire range, I undertook to map the distribution in Georgia. A study of herbarium specimens was of little help, as there was so little material available. Accordingly, additional herbarium material was collected. For most species the number of specimens added was much greater than that of the combined collections from Georgia in all the major herbaria in the United States.

Although no attempt was made to collect a specimen from each county in which a given species was observed, herbarium material for many species soon became so bulky that it was necessary to curtail collections for reasons of space. The effort to obtain a detailed distribution picture was not entirely abandoned. Small dot maps were prepared for each species. These were taken into the field

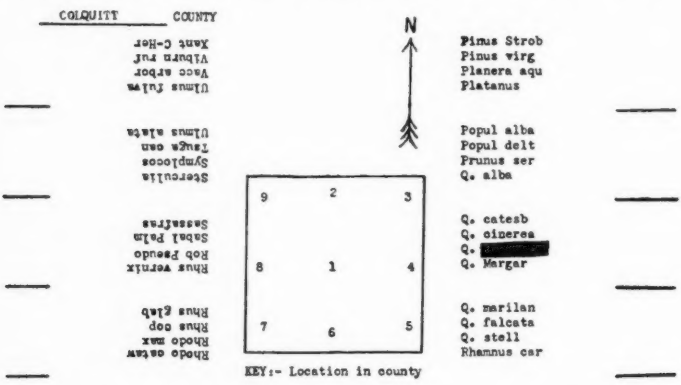

PLATE 1.—Keysort card for Colquitt County showing notched records for the county. The abbreviated names shown are for the ends of the card. The names for the long edges are on the other side of the card. Numbers from the "KEY: — Location in county" are used to indicate a more accurate position for any species at a critical part of its range. For example, the number "9" placed after the name of a species would indicate that the species was observed in the northwestern portion of the county.

and localities were recorded by placing circles on the maps. This method proved to be rather cumbersome and slow.

A much easier and faster method was devised in 1944. McBee Keysort cards (5 x 8 in.) were purchased and the names of 88 easily identified trees and a key to location in the county were mimeographed on them. Then one card was assigned to each county. The card for Colquitt County is illustrated in Plate 1. A notching punch was used to tabulate the occurrence of a species in a given county. If the locality was near the limits of the range of a given species, then a more accurate position was indicated by use of the numbers in the "Key Location in County."

After field observations over several years were concluded it was an easy matter to transfer the data to distribution maps. A Keysort needle was inserted in the hole for a given species and cards for those counties[1] in which the species had been observed dropped off the needle. Then an assistant using a drop pen was able to place circles for each county observation on the distribution map. This can be done rapidly; the entire procedure eliminated time consuming tabulation and sorting. It is thought that simplicity of the procedure reduced greatly the chance of errors entering into the data. No planted trees are included in the data. Only those growing naturally or those which propagated naturally from planted trees are recorded. The circles represent observations only, while the dots represent actual herbarium material. Data from this material are recorded on permanent records in the files of the University of Georgia Herbarium.

The species are presented here (see numbered list) in the order that they appear in the U. S. Forest Service Check List. The names of the 87 species[2] of this paper were checked by Dr. E. L. Little, Jr., for which assistance I am grateful. I am also indebted to Dr. Robert F. Thorne for valuable aid in checking herbarium material available to him at Cornell University. I, however, assume full responsibility for the contents of the entire manuscript. Financial assistance obtained through Dr. George H. Boyd, Dean of the Graduate School, University of Georgia, contributed both directly and indirectly to this study—the present study being done mostly concomitant to other projects. Some of the projects were supported by grants made through the research committee of the University Center in Georgia and by a research committee of the University of Georgia from funds made available jointly by the Carnegie Foundation and the University of Georgia.

Some of the physiographic features of Georgia (Plate 2) will be considered here so that the reader may more easily interpret the distributional picture for various species. At intevals reference will be made to the data shown in Plate 2. The location of lines of division between physiographic provinces has been a point of discussion, the Valley and Cumberland Provinces being most clearly

1 Twenty-one counties were never visited during the interval when the Keysort cards were being utilized. The counties are: Barrow, Bryan, Calhoun, Chatham, Dooly, Dougherty, Effingham, Heard, Lamar, Liberty, Lumpkin, McDuffie, Paulding, Peach, Quitman, Screven, Seminole, Terrell, Troup, Union, and Washington.

2 One of the original 88 species was dropped because of an error in preparing the Keysort card stencil.

defined. The separation of Blue Ridge and Piedmont is probably the most indefinite. This is emphasized by species that are predominantly of Blue Ridge distribution but are found in isolated localities in the Piedmont. These localities are usually of considerable relief, being either on slopes along streams or on isolated mountains like Kennesaw, Stone, or Sawnee, and have many features which are characteristic of parts of the Blue Ridge.

A number of inland plants are to be found on the Coastal Plain, especially near the western border of the state. Thorne (1949) presents several which occur on the Gulf Coastal Plain of Georgia. Several species included in the present study display a similar distribution pattern. Other species are confined in the Coastal Plain mostly to the relatively flat terraces of Late Miocene or of more recent origin. Suitable habitats are occasionally found farther inland

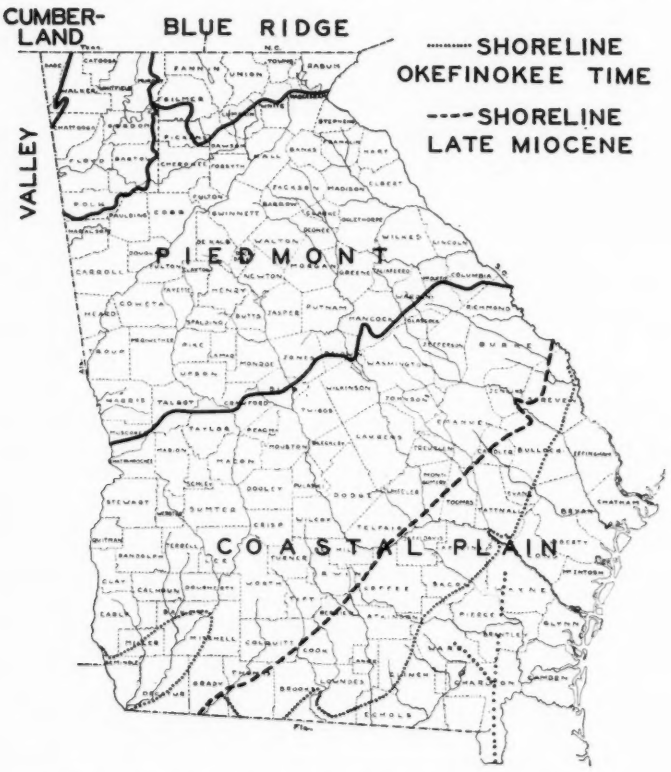

PLATE 2.—Map of Georgia showing counties, physiographic provinces, and the approximate location of ocean shorelines of the Late Miocene and Okefinokee Time.

but no generally large area is to be found, except that formed during Okefinokee Time by the extension of the shoreline inward in the southwest corner.

In a few species that are abundant on the Coastal Plain there are occasional stations on the Piedmont. Some of these Piedmont records can be attributed to escapes from plantings but others are probably relics of an earlier flora which once occurred on the Piedmont and later migrated mostly southward as areas became free for occupation.

The reader may gain some idea of the relative abundance of the various species by considering the relative number of records for each species of tree. If all species were equally easy to recognize, then the data would be absolute. This is not true, especially at certain times of the year. Dogwood in flower, for example, may be recognized positively from some distance—and so may *Aralia spinosa* L., *Chionanthus virginicus* L., and others. A tree like *Paulownia tomentosa* (Thumb.) Steud. may be recognized readily at any time, especially as compared to a species like *Ulmus alata* Michx. which must be examined closely for positive determination. By taking into consideration, therefore, both the ease of recognition and the relative number of records one may arrive at a fair idea of relative abundance. It would seem that *Diospyros virginiana* L. and *Toxicodendron vernix* (L.) Ktze. are approximately equal from the standpoint of ease of recognition. An examination of the maps for these species shows a marked difference in the number of records. This difference, therefore, should reflect rather accurately their relative abundance.

The abundance of a given species in one part of the state may be compared with that in other parts by noting the number of records and the list of counties which were not included in the Keysort card studies.

List of Species with Map Number and Miscellaneous Notes

1. *Pinus glabra* Walt. Spruce Pine. Apparently most abundant in southwestern Georgia.

2. *Pinus palustris* Mill. Longleaf Pine. The Piedmont records are from areas of considerable relief, mostly low mountains.

3. *Pinus pungens* Lamb. Table-Mountain Pine. Uncommon in the state.

4. *Pinus rigida* Mill. var. *serotina* (Michx.) Loud. Pone Pine. (*P. serotina* Michx.) I consider this as a species separate from *P. rigida* since they differ in leaves, cones, general appearance, habitat, and distribution. They are separated by at least 150 miles.

5. *Pinus strobus* L. Eastern White Pine. The Cherokee and Hall County stations are within the Piedmont and appear to be relics of a population formerly more southern than is true for the species today. The Cherokee collection is the southernmost in the United States and brings the distribution several miles farther south than the species was previously known to occur.

6. *Pinus virginiana* Mill. Virginia Pine. The range of this species is more extensive than was previously known. At least some of the trees in Clarke County occur in very sandy soil on high terraces along the Oconee River, a habitat approaching that of the quite similar *P. clausa* (Engelm.) Vasey. Perhaps a more careful study of the similarities and differences in these species would be profitable.

7. *Tsuga canadensis* (L.) Carr. Eastern Hemlock.

8. *Juniperus virginiana* L. Eastern Redcedar. [*J. silicicola* (Small) Bailey] There

seems to be considerable variability in *Juniperus* material from Georgia and I am unable to separate *J. silicicola* on the basis of the differences which are said to exist.

9. *Sabal palmetto* (Walt.) Lodd. Cabbage Palmetto.

10. *Juglans cinerea* L. Butternut. The Clarke County record is based on plants which propagated from trees planted along the Oconee River many years ago. Otherwise the species is confined to the Blue Ridge and Cumberland Provinces. It is absent in the Valley.

11. *Juglans nigra* L. Black Walnut. This species is apparently unable to find a suitable habitat throughout most of the Coastal Plain.

12. *Populus* alba L. White Poplar. Frequently planted and propagating abundantly by means of root shoots throughout most of the Piedmont. Rarely seen in the Blue Ridge, a direct correlation with the relative number of residences.

13. *Populus deltoides* Bartr. Eastern Cottonwood. The rarity of this species in the lower half of the Coastal Plain and its apparent absence from northwestern Georgia seem to be significant.

14. *Carpinus caroliniana* Walt. American Hornbeam. The almost complete absence of steep slopes overlooking streams, the characteristic habitat for the species, apparently contributes to its scarcity in the lower Coastal Plain.

15. *Ostrya virginiana* (Mill.) K. Koch. Eastern Hophornbeam. Much less abundant than the previous species, rare if not absent in the Blue Ridge but following a similar distribution pattern southward.

16. *Betula nigra* L. River Birch. I can offer no explanation for the apparent absence of this species from a large area in the Coastal Plain. This situation is worthy of further study.

17. *Fagus grandifolia* Ehrh. American Beech. This species is being regarded sensu latiore, much material as yet unnamed has been collected for study. The general pattern of distribution, however, is apparent from the data presented here.

18. *Castanea dentata* (Marsh.) Borkh. American Chestnut. Now represented almost entirely by stump sprouts.

19. *Quercus alba* L. White Oak. The lack of records for a large area in the Coastal Plain appears to be significant.

20. *Quercus cinerea* Michx. Bluejack Oak. Grows mostly on sandy soil, especially sandy ridges. The Clarke County record is apparently not an escape and may be a relic of the time when many now typically Coastal Plain plants occurred more abundantly in the Piedmont.

21. *Quercus falcata* Michx. Southern Red Oak (Spanish Oak). It is significant that this species is essentially absent from the Blue Ridge and Cumberland areas.

22. *Quercus laevis* Walt. Turkey Oak. (*Q. catesbaei* Michx.) Confined to sandy soils of the Coastal Plain.

23. *Quercus marilandica* Muenchh. Blackjack Oak. The absence from the Blue Ridge and parts of the Coastal Plain is of interest.

24. *Quercus stellata* Wangenh. Post Oak.

25. *Quercus stellata* Wangenh. var. *margaretta* (Ashe) Sarg. Dwarf Post Oak. (*Q. margaretta* Ashe) This tree of sandy soils seems to be distinct from *Q. stellata*. I regard it as a distinct species on the basis of morphological differences and the fact that the two populations do not seem to hybridize readily even when they grow in close proximity. The Clarke County records are on high sandy terraces along the Oconee River where it grows with *Q. stellata*. It is my opinion that this northernmost locality is not of recent origin but that this species, by migration from terrace to terrace, has been able to persist there since the time when it was more abundant in the Piedmont.

26. *Ulmus alata* Michx. Wingd elm. Although occurring in the Coastal Plain it is less abundant there than would be suspected by reference to Small (1933) and U. S. D. A. (1949).

27. *Ulmus fulva* Michx. Slippery Elm. This generally upland tree extends down into the Gulf Coastal Plain.

28. *Planera aquatica* (Walt.) Gmel. Planertree. Probably more abundant than indicated by the records, as this species grows in river swamps, many of which are not readily accessible.

29. *Celtis laevigata* Willd. Sugarberry. Apparently absent from certain parts of the state.

30. *Morus alba* L. White Mulberry.

31. *Morus rubra* L. Red Mulberry.

32. *Broussonetia papyrifera* (L.) Vent. Paper Mulberry. Propagating abundantly by means of root suckers from planted trees.

33. *Maclura pomifera* (Raf.) Schneid. Osage-orange. At least a majority of the stations in Georgia are trees that have propagated from planted trees. It is doubtful if any are native to the state.

34. *Magnolia fraseri* Walt. Fraser Magnolia. (*M. pyramidata* Pursh) Much of the material from exposed trees of the Blue Ridge seems indistinguishable from collections from southwest Georgia. I am, at this time, inclined to consider all the material from Georgia as one species.

35. *Magnolia grandiflora* L. Southern Magnolia. Occurring much farther inland, to within a few miles of the Piedmont in Washington County, than it was previously thought to grow naturally.

36. *Magnolia macrophylla* Michx. Bigleaf Magnolia. This tree seems to be most abundant in Bartow and Cherokee Counties. Its distributioin is not continuous, however, over any considerable area.

37. *Magnolia tripetala* L. Umbrella Magnolia. More abundant than the last species but not a common tree. According to Coker (1945) Dr. Francis Harper reports it from Effingham County.

38. *Magnolia virginiana* L. Sweetbay. This common tree of the Coastal Plain is spotty in its distribution in the Piedmont.

39. *Liriodendron tulipifera* L. Yellow-poplar. It may be noted that this tree is least common in the lower Coastal Plain.

40. *Sassafras albidum* (Nutt.) Nees. Sassafras. This species is also least common in the lower Coastal Plain.

41. *Hamamelis virginiana* L. Witch-hazel. Found throughout the state but one of the less common trees.

42. *Liquidambar styraciflua* L. Sweetgum. Seemingly absent from the higher elevations in the Blue Ridge. One of the most common trees of the state.

43. *Platanus occidentalis* L. American Sycamore. Very easily identified from a distance by the white bark on older trees. It, therefore, is not as abundant as would be indicated by comparing the number of records with those of other species.

44. *Prunus caroliniana* (Mill.) Ait. Carolina Laurelcherry. [*Laurocerasus caroliniana* (Mill.) Roem.] This plant grows naturally along the coast and in southwest Georgia. Inland records are due to plants escaping from cultivation. This probably is true of the Richmond County area, even though it occurs in extensive, pure stands in some places.

45. *Prunus serotina* Ehrh. Black Cherry. No attempt is made here to separate *P. cuthbertii* Small as I am not prepared to pass on the validity of the species. *P. alabamensis* C. Mohr is considered as distinct.

46. *Albizia julibrissin* Durazz. Silktree. This introduced tree has escaped in many localities by means of propagation from seeds. It has already become an important component of secondary growth in localized areas. Its absence from parts of the Coastal Plain and northwest Georgia is significant.

47. *Cercis canadensis* L. Eastern Redbud. This species is abundant over large areas of the state but is uncommon in the Blue Ridge and most of the Coastal Plain.

48. *Gleditsia aquatica* Marsh. Waterlocust. One of the more uncommon trees of the state.

49. *Gleditsia triacanthos* L. Honeylocust. Although said not to be native in Georgia, it would seem to me that it would be difficult to eliminate positively some of the records in northern Georgia.

50. *Robinia pseudo-acacia* L. Black Locust. Thought to be native in the Blue Ridge and Cumberland Provinces and naturalized elsewhere. It is now abundant in many places in the Piedmont.

51. *Xanthoxylun clava-herculis* L. Hercules-club. This species occurs near the coast and in southwest Georgia.

52. *Ailanthus altissima* (Mill.) Swingle. Ailanthus. This introduced tree is adventive over the northwestern half of the state having escaped most frequently near cities. It occurs occasionally in the woods and seems to be able to compete successfully with native trees.

53. *Melia azedarach* L. Chinaberry. Introduced but, except for the Blue Ridge, escaping throughout the state.

54. *Rhus copallina* L. Shining Sumac.

55. *Rhus glabra* L. Smooth Sumac. Notably absent from most of the Coastal Palin.

56. *Toxicodendron vernix* (L.) Ktze. Poison Sumac. (*Rhus vernix* L.) Scattered throughout most of the state but in most places an uncommon species, which is much to man's advantage.

57. *Cyrilla racemiflora* L. Swamp Cyrilla. This is a tree of moist habitats, rarely occurring out of the Coastal Plain.

58. *Cliftonia monophylla* (Lam.) Britton. Titi. This species also prefers a moist habitat and has a more restricted range than the preceding species.

59. *Ilex myrtifolia* Walt. Myrtle Dahoon. Another species preferring wet places and being confined to the Coastal Plain where locally it is common.

60. *Ilex opaca* Ait. American Holly. Occurring throughout the state, a considerable number of trees usually occurring at any one locality.

61. *Ilex vomitoria* Ait. Yaupon. Common along the coast. Many of the stations farther inland are known definitely to be at old Indian Village sites. This suggests that the plant was introduced by Indians. If so, this is one of the earliest of our adventive trees, excluding, of course, the coastal area. A more careful study should be both profitable and interesting.

62. *Acer negundo* L. Boxelder. Although this species is recorded as occurring throughout Georgia (U. S. D. A., 1949), it is certainly rare in both the Blue Ridge and most of the Coastal Plain.

63. *Rhamnus caroliniana* Walt. Carolina Buckthorn. Not a common plant in Georgia, rarely seen outside of the eastern Piedmont.

64. *Firmiana platanifolia* (L. f.) Schott & End. Chinese Parasol tree. (*Sterculia platanifolia* L. f.) Escaped from cultivation in two counties.

65. *Gordonia lasianthus* (L.) Ellis. Loblolly-bay. This beautiful flowered tree of tropical affinities has been able to migrate inland beyond the late Miocene deposits.

66. *Lagerstroemia indica*. L. Common Crapemyrtle. Escaping from planted trees. The

tendency toward clustering of the records is attributed to localized emphasis on usage of this tree as an ornamental. It was observed that in some areas the tree was used abundantly. In others the species was rerely seen.

67. *Aralia spinosa* L. Devils walkingstick. Not as common as would be indicated by the number of records as compared to other species. This is due to easy identification at time of flower. It is significant that this species was not observed in a large area of the Coastal Plain where it is certainly rare or perhaps absent.

68. *Nyssa aquatica* L. Water Tupelo. The Newton County record places his tree farther into the Piedmont than it was previously thought to grow. It is probably more abundant in the Coastal Plain than these records show, since it grows in rather inaccessible swamps.

69. *Nyssa ogeche* Bartr. Ogeechee Tupelo. Abundant in the lower Coastal Plain and abruptly disappearing to the northwest.

70. *Cornus alternifolia* L. f. Alternate-leaf Dogwood. Most abundant in the Blue Ridge but also common locally southward to southwestern Georgia.

71. *Cornus florida* L. Flowering Dogwood. Apparently rather uncommon or absent in the central part of the Coastal Plain.

72. *Rhododendron catawbiense* Michx. Catawba Rhododendron. Confined to mountainous areas. The Cherokee County station is probably the southernmost for the species. This species may be found from as low as 900 feet above sea level to over 4700 feet.

73. *Rhododendron maximum* L. Rosebay Rhododendron. Also confined to mountainous areas but absent from the Cumberland.

74. *Kalmia latifolia* L. Mountain-laurel. Common in the Blue Ridge, Cumberland and Pine Mountain area of the Piedmont. Southward it occurs mostly on steep slopes usually along streams.

75. *Oxydendrum arboreum* (L.) DC. Sourwood. Most abundant in north Georgia but also found southward into the Coastal Plain. It seems to prefer hilly territory.

76. *Vaccinium arboreum* Marsh. Tree Sparkleberry. This species seems to be approximately equally abundant in the Piedmont and Coastal Plain and absent from the Blue Ridge. It is often locally abundant or locally absent.

77. *Bumelia lycioides* (L.) Pers. Buckthorn Bumelia. This is one of the more uncommon trees. It seems to be equally uncommon in both the Piedmont and Coastal Plain.

78. *Diospyros virginiana* L. Common Persimmon. Probably less common in the Blue Ridge than elsewhere.

79. *Symplocos tinctoria* (L.) L'Hér. Common Sweetleaf. Not especially common over large areas except in southwest Georgia where it is not difficult to find specimens, especially when they are conspicuous in flower.

80. *Halesia diptera* Ellis. Two-wing Silverbell. This two-wing silverbell is not a common tree and has a limited, and spotty distribution.

81. *Chionanthus virginicus* L. Fringetree. When in flower probably the most readily identified species of this group. The reader should note the absence of records from much of the Blue Ridge and a large area of the Coastal Plain.

82. *Osmanthus americanus* (L.) Benth. & Hook. f. Devilwood. Almost entirely a plant of the Coastal Plain.

83. *Paulownia tomentosa* (Thumb). Steud. Royal Paulownia. This tree has been planted abundantly and seems to escape readily. It, however, apparently does not do well in the Coastal Plain.

84. *Catalpa bignonioides* Walt. Southern Catalpa. The absence of records from near the coast appears to be significant.

85. *Pinckneya pubens* Michx. Pinckneya. The distribution of this striking tree has

been rather accurately determined. It is much collected because of its spectacular appearance while in flower. It is, therefore, more uncommon than the number of records would indicate.

86. *Cephalanthus occidentalis* L. Common Buttonbush.

87. *Viburnum rufidulum* Raf. Rusty Blackhaw. Not especially common anywhere and probably absent from some parts of the state.

A number of people have expressed considerable surprise at the distributional picture presented for various species included in this study. In most instances an overestimate was made of the time consumed in compiling the data. Although considerable effort was expended, many times as much work would have been necessary, if the Keysort cards had not been used. It is urged that taxonomists consider the possibility of use of such cards in tabulating data especially in the field. The time expended in the field is so small that the results obtained would well repay the effort made even though further studies may need to be made on certain populations, such as are included under *Fagus grandifolia* and *Prunus serotina* in the present study. Detailed studies will probably never be necessary for most of the species, and, therefore, tremendous amounts of time can be saved. It is planned to utilize the Keysort cards for other plants, especially species such as mistletoe and spanish moss which are easy to identify but hard to collect. Important species such as poisonous plants and weeds will be included. Collection of specimens of those species being tabulated will not be abandoned. A sufficient number will be obtained, as they were in the present study, to allow discovery and study of significant variations within the population. One is not justified, therefore, in interpreting the present and similar, future studies as being "window botanizing."

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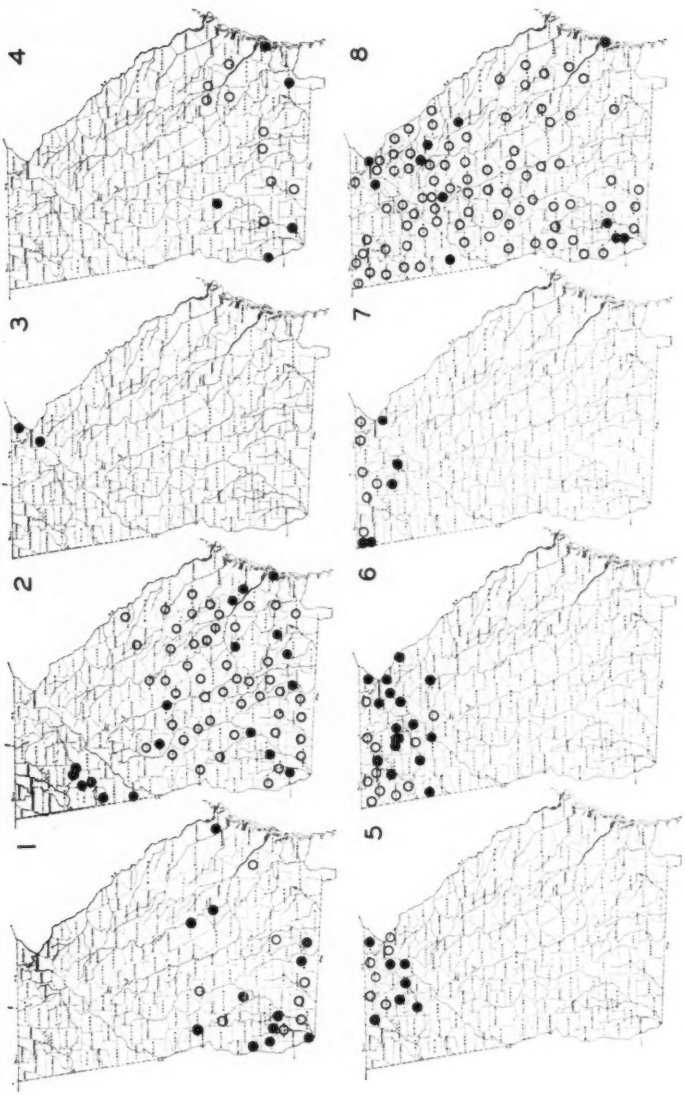
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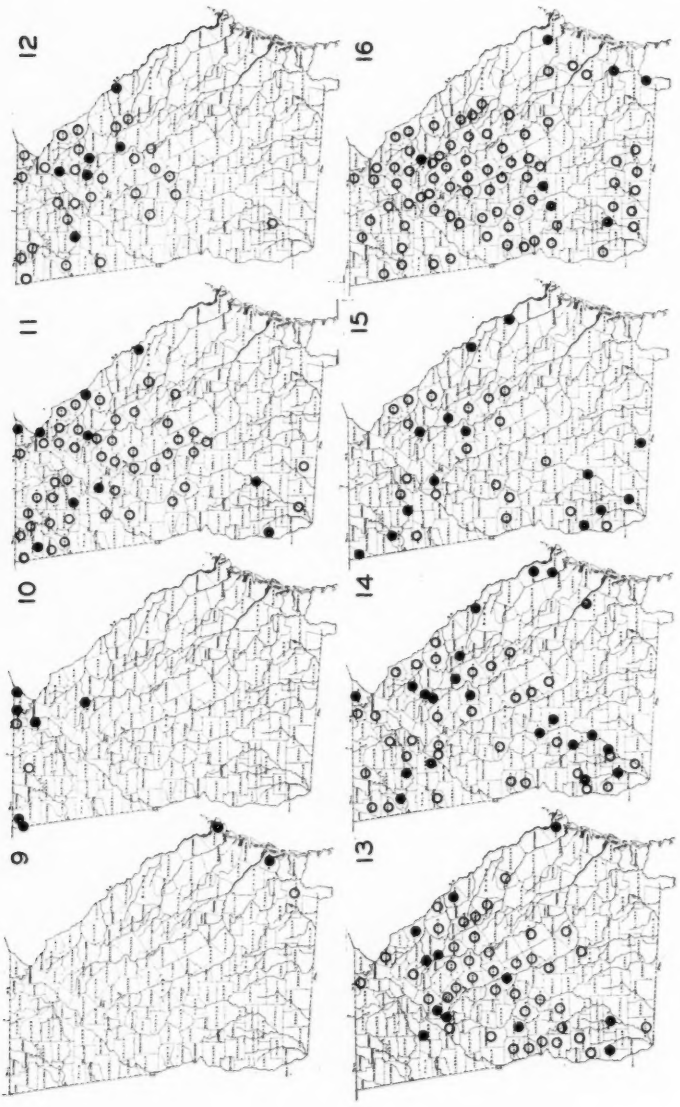
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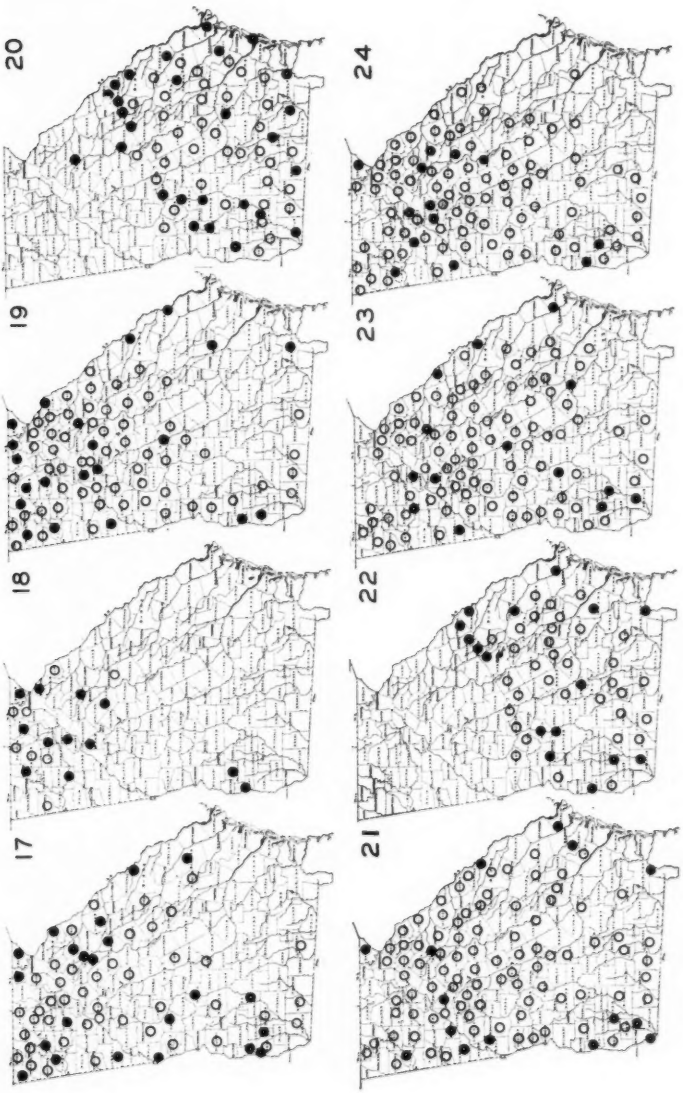
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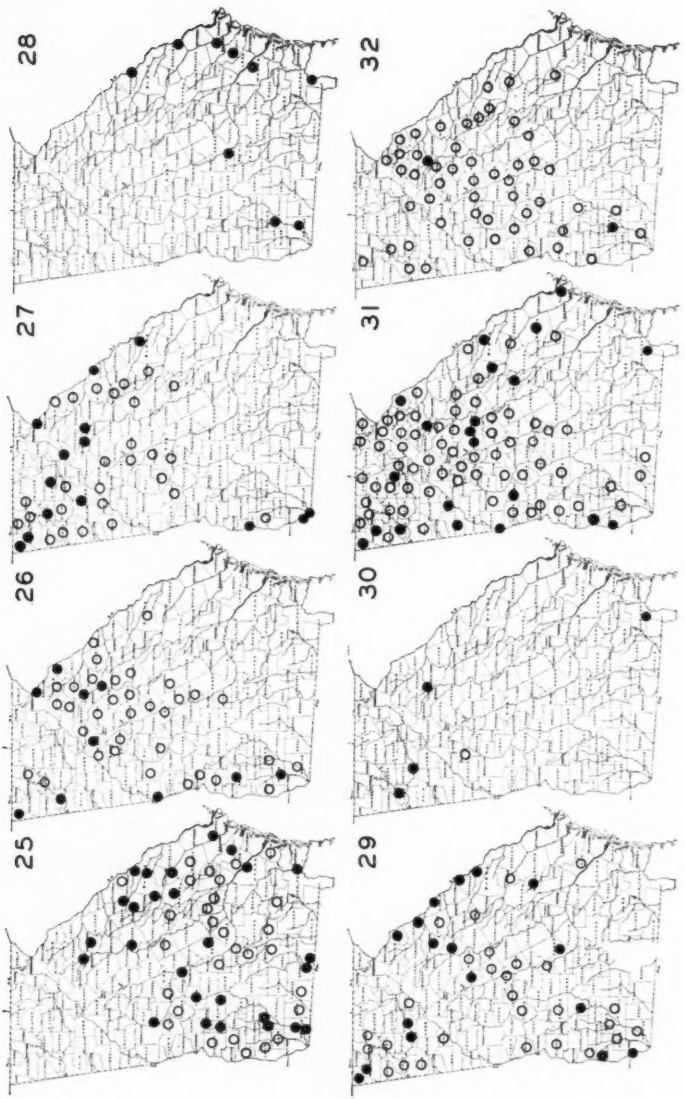
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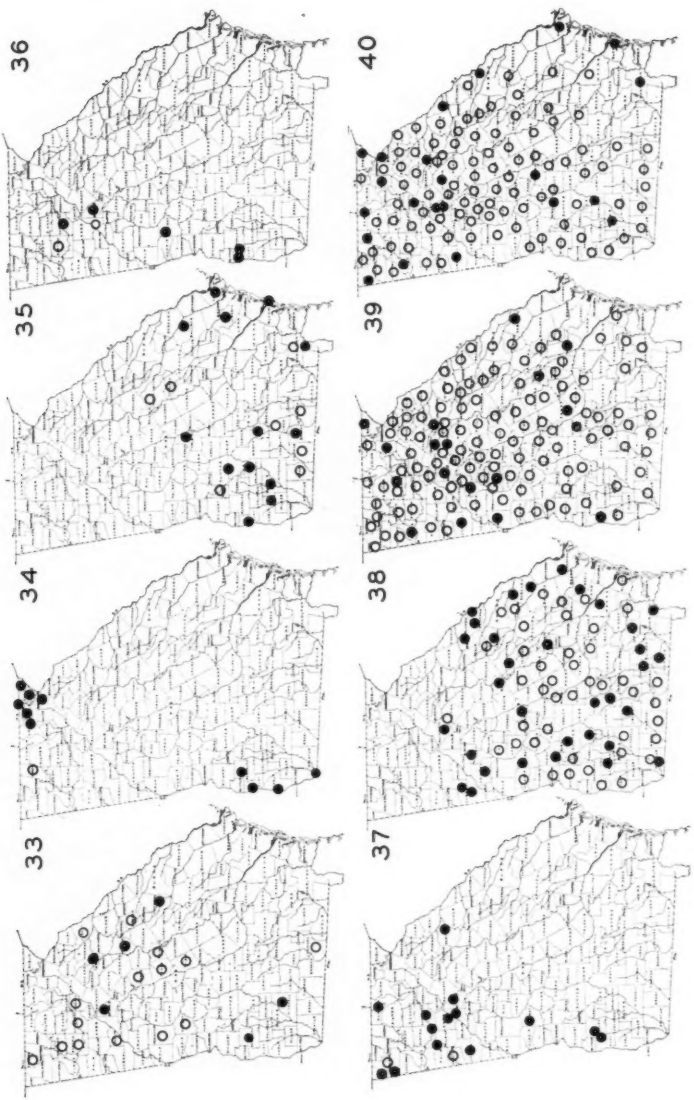
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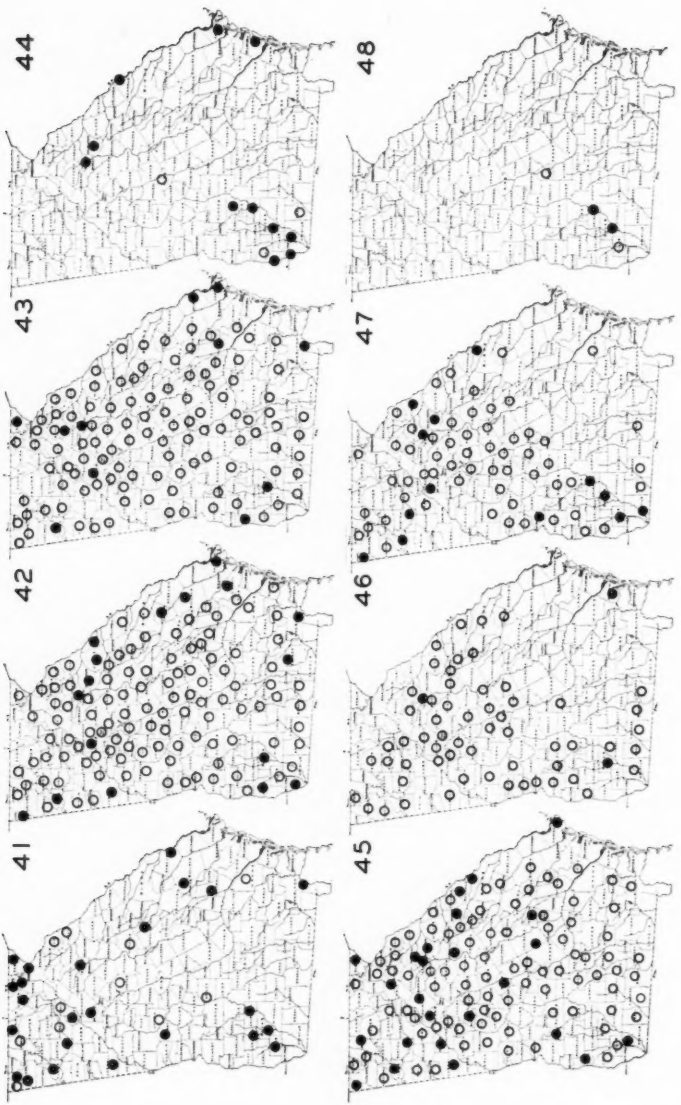
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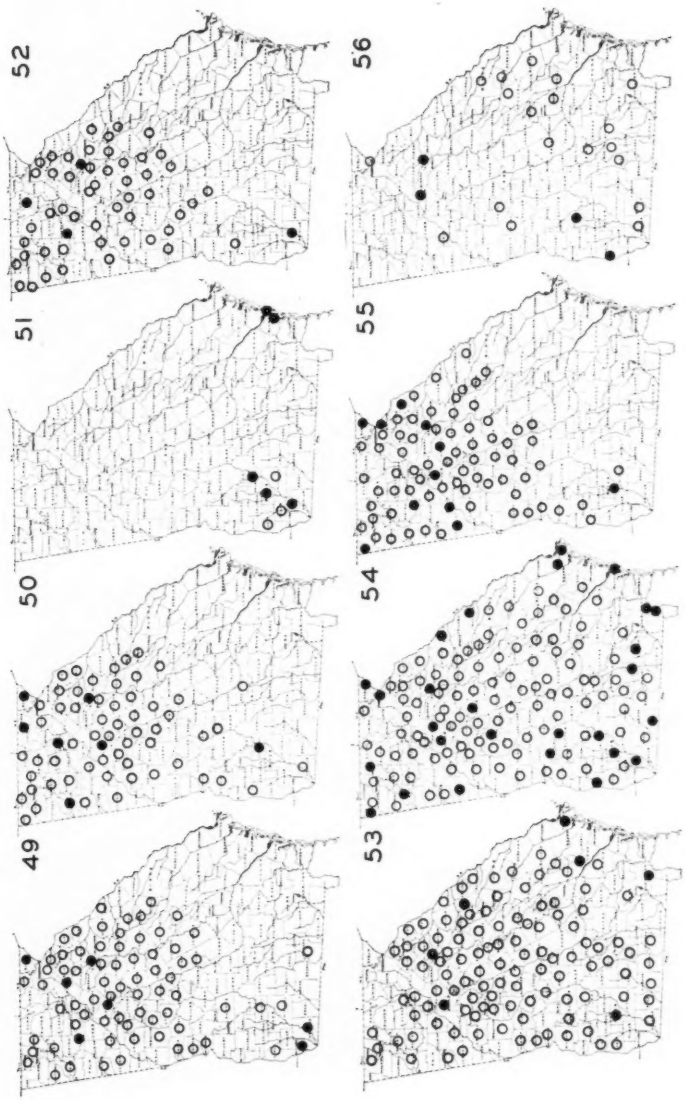
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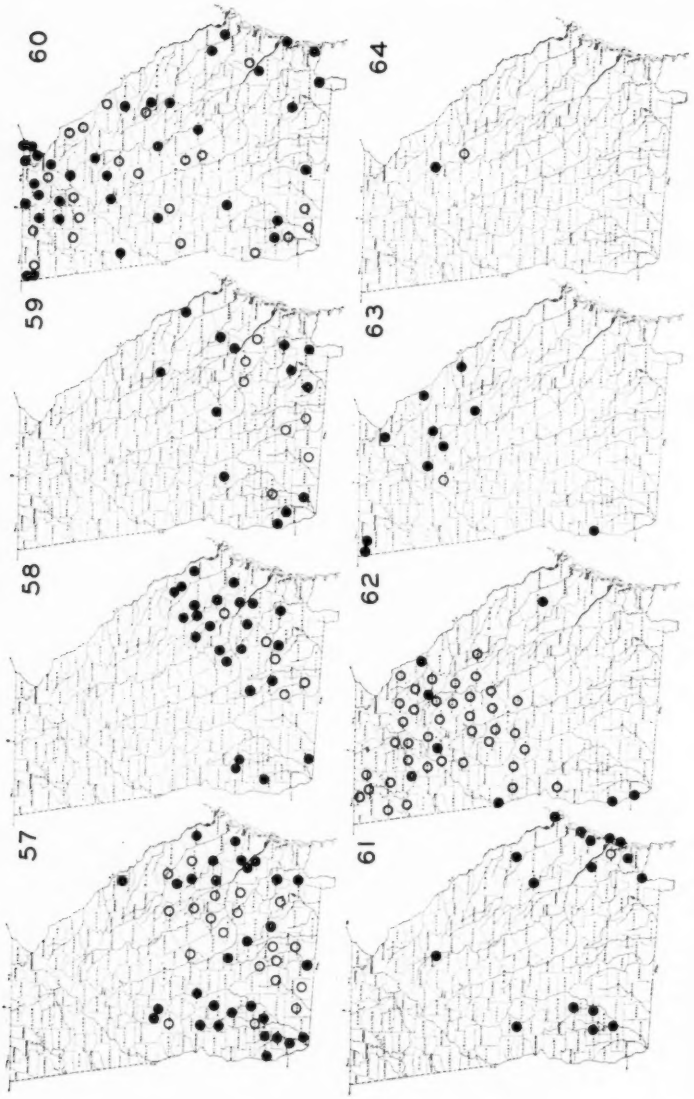
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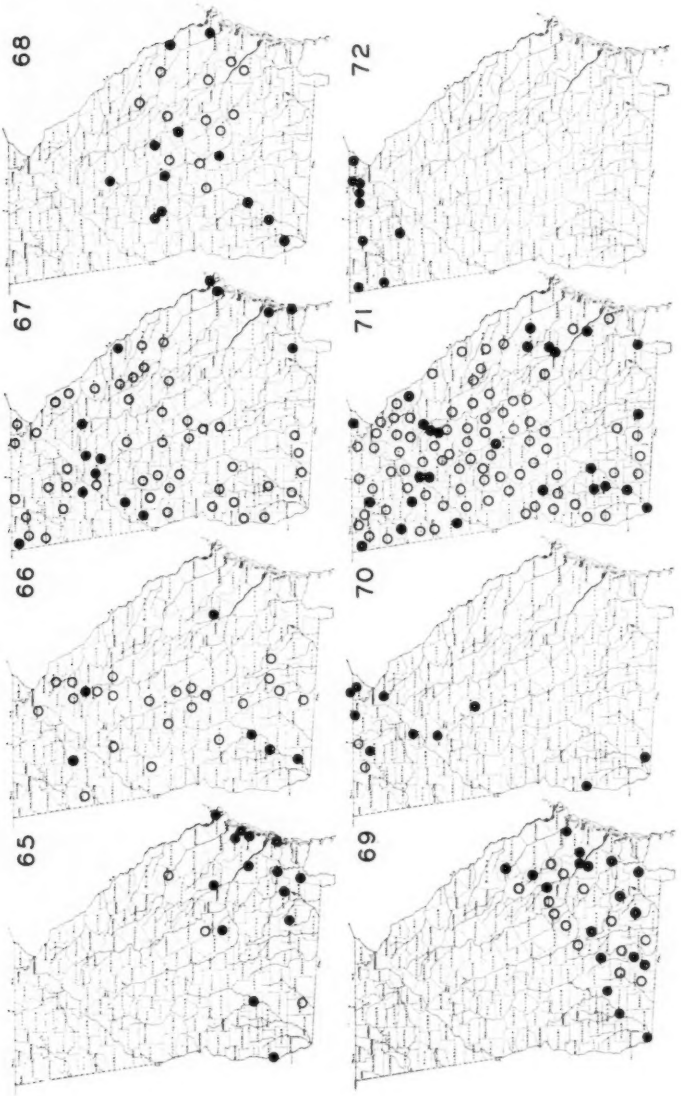
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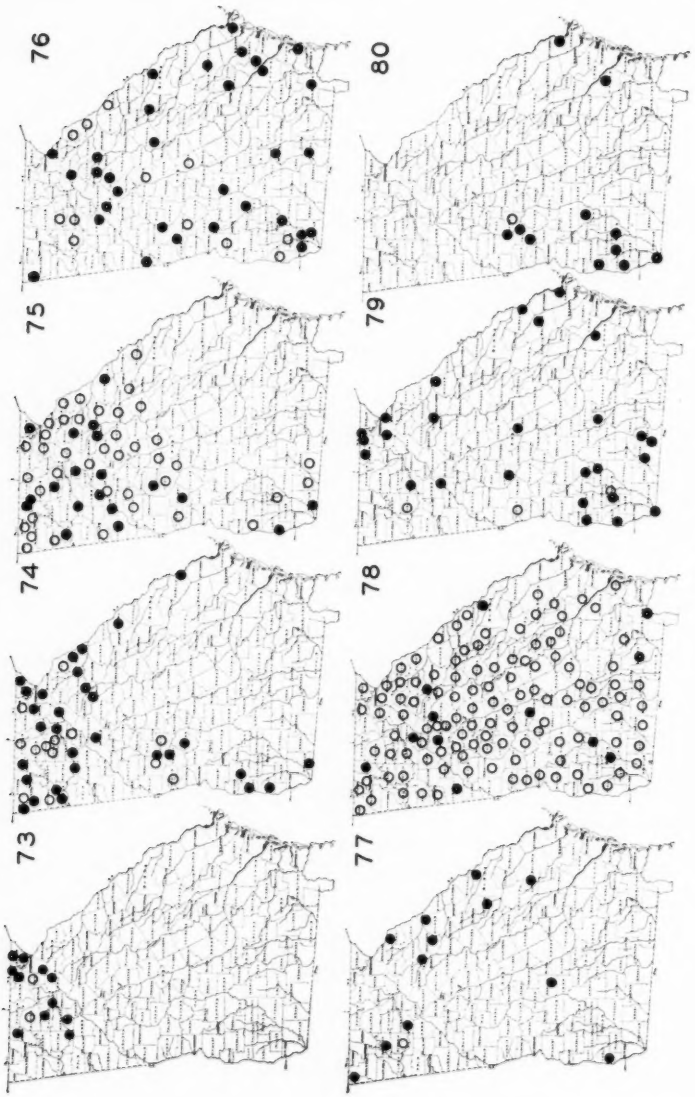
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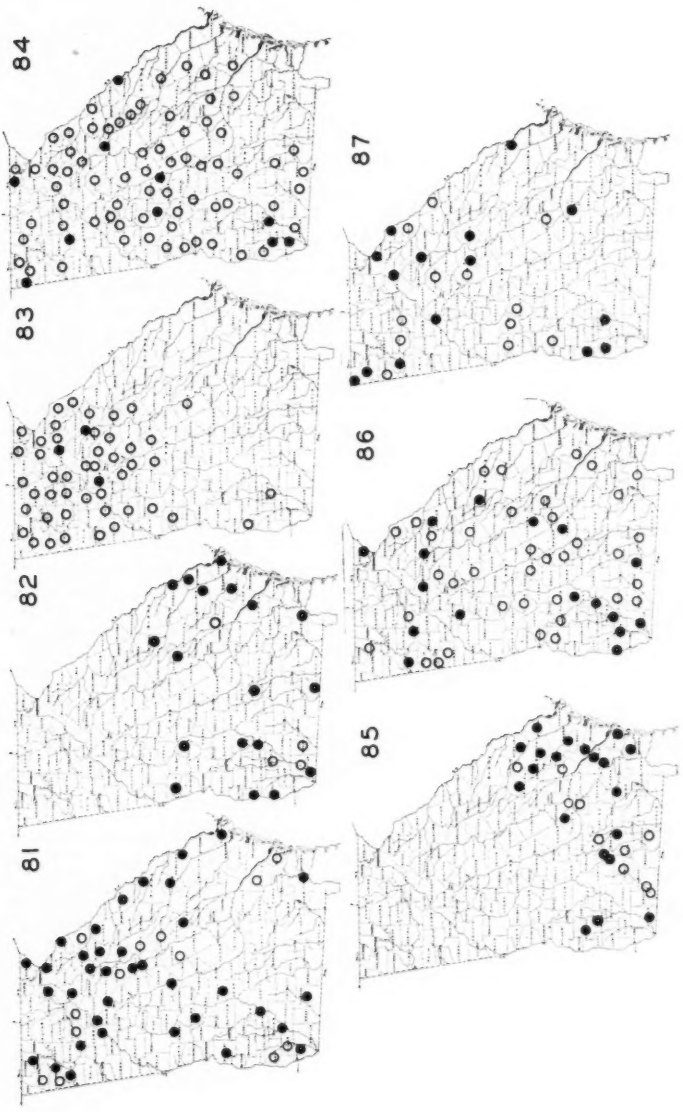
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Notes and Discussion

The Juvenile State of Elymus canadensis[1]

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The several sets of uncorrelated variations of *Elymus canadensis* in Minnesota have been discussed[2]; the writer had independently reached much the same conclusion concerning that species in Wisconsin.

On sandy shores at the eastern end of Lower Red Lake, Beltrami County, Minnesota, *Elymus canadensis* was found to occur in two quite dissimilar phases. About half the plants were quite normal for that species: the culms were in large clumps and reached about 1 meter in height, the spikes were some 20 cm. long with 2 spikelets at each node, the lemmas were short-hirsute, the palea of the lowest floret was 12 mm. long, and the grains, at the time of collection (July 31, 1949) were well-developed but not quite mature.

Nearby there were many slender dwarfed grasses that would not at first sight be taken for an *Elymus*. The culms were 15-20, rarely 40, cm. tall, usually solitary, the spikes were 3-7 cm. long, with most of the spikelets solitary at the nodes, and while stamens and pistils seemed normal the ovaries had not enlarged. The spikelets themselves were, however, almost identical with those of their larger neighbors, only a little smaller, with paleas about 9 mm. long.

Between the normal plants and the dwarfs there were no intermediates; the aspect was that of two quite disjunct populations. However, the slender and almost simple bases of the dwarfs gave a clue, and the presence of lemma and remains of a grain at the base of 3 individuals confirmed the fact that these were only first-year plants.

Dr. E. L. Nielsen tells me that in growing *Agropyron* he has not infrequently observed the flowering of plants in their first year; such plants are, however, so late in flowering that seeds are not set. Such appears to be the case also in *Elymus canadensis*. It is not common in a perennial of this type to find a large number of flowering seedlings at one time. The result of this unusual occurrence is, in this case, a population made up of plants of such diverse appearance and characters that they would, by too rigid reliance on any current keys to the *Hordeae*, be placed in different species or even different genera.

New and Interesting Plant Records. II

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Field and herbarium work during the past year have brought to light several additional plant records which seem to be of unusual interest.

Arctium minus f. *albiflorum* Beger—Along roadside, alt. 2800 feet, Pine Mountain, Letcher County, Kentucky, September 1, 1947, *H. N. Moldenke* 19361. This white-flowered form occurs sporadically with the typical form, but is not listed by name in our current manuals.

Dioscorea batatas Decaisne—Escaped in waste ground, Watchung, Somerset County, New Jersey, August 21, 1947, *H. N. Moldenke* 19133. This Chinese species escapes readily because of its aerial tubers, but is not listed in current manuals.

Epilobium hirsutum L.—In moist meadow along roadside Drumgoole Boulevard, Staten Island, Richmond County, New York, August 20, 1947, *H. N. Moldenke* 19121.

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1 Contribution No. 10 from the Lake Itasca Forestry and Biological Station, University of Minnesota.

2 Booher & Tryon, Rhodora 50: 86-87. 1948.

This species is said by Britton & Brown to extend south to "central New York," although Gray's Manual extends the range to "s. N.Y." The record from Staten Island seems worthy of note as confirming the Gray's Manual statement.

Eriocaulon cinereum R. Br.—Plants submerged except for the upper part of the flowering stems, in the Krause rice fields, Modesto, Stanislaus County, California, September 18, 1947, *B. G. Markos s.n.* This appears to be the first record of this Asiatic rice-field species from America. The California specimens seem larger and huskier in all parts than typical material of the species examined from various parts of Asia, but come within the dimensions given for the species by Ruhland in his monograph of the family.

Persicaria longiseta (De Bruyn) Kitagawa—At base of cliffs along stream, Marshall, Madison County, North Carolina, August 31, 1948, *H. N. Moldenke* 19329. This is the first record known to me of this species south of Virginia. It is not listed in Small's Manual.

Plantago lanceolata var. *lanuginosa* Mert. & Koch—In dry sandy field, North Eastham, Barnstable County, Massachusetts, July 30, 1947, *H. N. Moldenke* 19029. This very distinct variety is not listed in current manuals.

Rorippa indica (L.) L. H. Bailey—Common weed under rhododendrons, New York Botanical Garden, Bronx Park, Bronx County, New York, June 2, 1947, *H. N. Moldenke* 18653, det. Rollins. This species is not listed in current manuals.

Tragopogon dubius Scop.—In sandy waste ground, Arverne, Queens County, New York, June 21, 1947, *H. N. Moldenke* 18672. This species is not listed in current manuals, except in G. N. Jones' Flora of Illinois, page 270.

A New Orchid for Illinois

GLEN S. WINTERRINGER
Illinois State Museum, Springfield

The first Illinois collection of *Hexalectris spicata* (Walt.) Barnh.[1] adds a new genus to the Orchidaceae of the state. This rare orchid was found July 13, 1949 near Prairie du Rocher, Randolph County, in southwestern Illinois.

Three to four plants averaging eighteen inches in height were observed in two well-separated groups beside an old trail where the soil was well packed. The habitat was an oak-hickory woods on a rocky, limestone slope. The following plants are associates of *Hexalectris spicata* (Walt.) Barnh.: *Hystrix patula* Moench. *Monarda bradburiana* Beck., *Ceanothus americanus* L., *Rhus aromatica* Ait., *Petalostemum candidum* (Willd.) Michx., *Ratibida pinnata* (Vent.) Barnh., *Rudbeckia hirta* L., and *Vernonia baldwini* Torr.

Future exploration of the same locality may reveal more frequent occurrence of this orchid than the initial collection indicates. It should be regarded as a rare plant and collected with caution.

Previous collections of *Hexalectris spicata* (Walt.) Barnh. have been recorded for states bordering Illinois, i.e.: Indiana,[2] Missouri,[3] and Kentucky.[4]

Specimens of this Illinois collection, (No. 2058), have been deposited in the Herbarium of Illinois State Museum, Springfield and in the Herbarium of the University of Illinois. Verification of identity of the orchid was made by Dr. G. D. Fuller and Professor G. Neville Jones.

1 Rhodora 17: 136. 1915 and Torreya 4: 121. 1904.

2 Deam, C. C. Flora of Indiana. 1940.

3 Palmer, E. J. and Steyermark, J. A. An Annotated Catalogue of the Flowering Plants of Missouri. 1935.

4 Braun, E. Lucy. An Annotated Catalog of Spermatophytes of Kentucky. 1943.

Book Reviews

PLANT ECOLOGY. By W. B. McDougall. Lea and Febiger, Philadelphia. 1949. Fourth edition, 234 pages, 118 illus. $4.00.

The author of this well-known text believes that, despite the vigorous growth of the science of ecology as indicated by the mounting output of research, little of a fundamental nature has been added to the earliest recognized basic principles. He further believes that the plan and content of previous editions of *Plant Ecology* satisfactorily treat those basic principles and adequately fulfill the requirements of students exposed to ecological science for the first time. Accordingly the appearance of the fourth edition is marked more by revision in an editorial sense than by any change in conception of what a text should do for the student.

This edition contains the same subject matter with the same organization and, except for the frontispiece, the same illustrations as the third edition. Changes include a certain amount of rephrasing without alteration of content, occasional addition or deletion of sentences necessary to more modern interpretations of certain biological phenomena, and rarely the addition of scattered paragraphs of new subject matter. The lists of references appearing at the end of each chapter have been modified somewhat in most cases by deletion of certain of the older references and usually by the addition of one or more well-chosen recent publications.

The most extensive single change is the addition of about three-fourths of a page of text on the assumptions and methods of pollen analysis as a means of studying past successions. Other new materials include some elaboration on previous treatment of the physical factors of the environment, particularly with reference to the effects of light on pigmentation, light tolerance of certain trees of the southeastern pine belt, the ecological role of fire, the physical state of water in soils, and factors affecting the rate of humus decomposition. A number of minor corrections or additions have been made pertaining to root growth under swamp conditions, digestive enzymes of insectivorous plants, water relations of *Tillandsia*, causal mechanisms in gall formation, the role of mosses and lichens in xeroseres, effects of overgrazing, the role of daylength in phenology, and the problem of shifting timberlines as evidence of climatic change. The interpretation of certain forest types has been somewhat modified, largely by omission of the former discussion of Oak-pine forests and by relocation of the Oak-Chestnut-Tulip Association.

The text has been entirely reset and more efficient use made of the printed page. The margins are appreciably smaller than in the preceding edition with the result that the number of pages has been materially decreased without detriment to the text. There are a number of typographical errors, the most glaring of which are the page headings in Chapter V, "Symbiosis—Disjunctive," and Chapter VII, "Reciprocal Nutritive Disjunctive Symbiosis," which at least in the copy examined have become "disfunctive."—M. E. BRITTON, Northwestern University, Evanston, Illinois.

EXPERIMENTAL EMBRYOLOGY. By Roberts Rugh. Burgess Publishing Company, Minneapolis, Minn. 1948. Revised edition, vii+480 pages, diagrams and photographs. $6.00.

Experimental Embryology, a manual, reference source and textbook in part has, as the author states, as its subject matter the *embryo*. It is organized primarily for laboratory work in experimental embryology but is so designed that it can serve as a sourcebook of information to instructors who wish to augment standard embryology courses with some of the dynamic phases of development or even assist in active research. Notable throughout the book is the author's attempt to include the most current reference material available at the time of publication.

The first section deals with techniques in experimental embryology. This includes not only methods of constructing standard tools for laboratory owrk but also has hints, sources for obtaining materials, and preserving and staining techniques which make it possible for both student and instructor to proceed with operative work with a minimum of searching for proper methods.

The majority of the manual deals with amphibian development and is organized into individual experiments on progressive stages of development. The author has thoughtfully included in early chapters certain ecological and taxonomic features which make it a source of information in a condensed form which is helpful to the collector.

One needn't in this review list each experiment but call attention only to the fact that each is set up and described so as to stimulate development of analytical observation by the student. Commendably, each experiment does *not* end with a set of "thought questions" which would tend to stereotype the student's direction of analysis of the data; he is provided with proper directions and references and asked to call on his own analytical capacities. There are more experiments in this section than can possibly be completed by a single student in a year's time but this leaves considerable leeway for selection of materials for study or for allowing different students to undertake different problems as is seen fit.

In addition to classical experiments stemming from the "Entwicklungsmechanik" school, the author has included a few pertinent experiments on the physiology of development and some cytological work. No one experiment should leave the student with the idea that he has expended all possible approaches or ramifications of the problem under consideration.

The latter part of the manual is divided into sections on the experimental embryology of the fish and of the chick. In the section on the fish, a variety of species is described as suitable for experimental study; however, as would be expected, most of the experiments are drawn from studies on *Fundulus heteroclitus*. Nevertheless, with the information available in this section, it should now be possible for instructors in most sections of the country to provide fish material for experimental study. In general the methodology is similar to that of the section on amphibians.

The section on chick embryology is especially significant since it was the first place, to the reviewer's knowledge, that Spratt's significant work on avian morphogenetic movements was compiled and made readily available. In view of the extensive coverage of the section on amphibian development, the author has limited this section to morphogenetic movements and to chorio-allantoic graft procedure with several representative types of grafts as examples.

The reviewer has used this manual with graduate and undergraduate students and has found it to be excellent. Very seldom questions arise which involved procedure. If any criticism could be offered of the book, it is the lack of an index. The difficulty of compiling an index for a publication of this nature is fully realized; however, there are so many small but important points of technique condensed in it that it was sometimes time-consuming to search for the proper place of mention of a particularly needed one.

Since this publication is the product of many years' preparation by Dr. Rugh of laboratory materials and technique for his own students, it is to be supposed that he will continue to include new and current data and materials when they become available in the literature. It is suggested therefore that it would be convenient to have the manual published in loose-leaf form and that periodical additions or alterations could be made by subscription. If the latter part of the suggestion would not be workable, it would still be convenient to have the loose-leaf feature so that instructors could add their own exercises and that completed experiments by the student could more easily be assembled into complete units. It is realized that the format of the book was intended to be a working manual since space is provided for drawings and photographs. Nevertheless, it would be helpful in training students in methods of assembling materials for publication if each individual experiment could be extracted from the book and assembled with the student's written observations and conclusions. However, in view of the excellence of other features of the manual, this criticism is to be considered a minor one.—L. E. DELANNEY, Wabash College, Crawfordsville, Indiana.

INTRODUCTION TO GENETICS AND CYTOGENETICS. By Herbert Parkes Riley. John Wiley and Sons, Inc. 1948. 596 pp. + xii, 154 figures, 26 tables. $5.00.

This is one of the most nicely organized genetics texts which has yet appeared. The first five chapters provide a summary of general biological information which is apropos of genetics. Chapters 6 through 13 take up elementary Mendelism, while chapters 14 through 25 discuss some of the more complicated aspects of Mendelian genetics together with physiological genetics. The last seven chapters discuss cytogenetics. The cytological viewpoint predominates throughout the book. Illustrations are numerous, and, on the whole, good.

But the reviewer finds this book something of a disappointment. Courses in genetics are commonly presented on three different levels: a very elementary primarily cultural, course, without prerequisites; a more thorough and substantial course for students who are majoring in biological sciences; and finally, courses for graduate and advanced undergraduate students emphasizing cytogenetics and physiological genetics. Riley's title, and his excellent bibliography, indicate that he had the third, or at least the second, course in mind. But too much of the text is written on the first level. The five chapter introductory section, for example, could well have been condensed into a single chapter, for all of its contents should have been covered in prerequisite courses.

There is need for a textbook of genetics written from a cytological viewpoint. Professor Riley should be commended for attempting to fill that need. But a book written more consistently on one level would satisfy this need more effectively than the present book.—EDWARD O. DODSON, University of Notre Dame, Notre Dame, Indiana.

LARVAE OF INSECTS, Part I, LEPIDOPTERA AND PLANT INFESTING HYMENOPTERA. By Alvah Peterson. Edwards Brothers, Inc., Ann Arbor. 1948. 315 pages, 84 plates. $5.00.

It is almost axiomatic that publications dealing with insect pests should describe and figure the adults, even though the damage is always done by the larvae, so it is indeed a pleasure to report such a book as Dr. Peterson has produced. We hope that he does not long delay his projected second volume, and that his example will serve to spark other comprehensive studies among the important larval stages of the 70,000-odd species of holometabolous insects within our borders.

The present volume is primarily concerned with Lepidoptera and certain Hymenoptera, but it also introduces the subject of immature stages in a brief but adequate manner. A short introductory chapter discusses the importance of the field (some 60% of insect pests are destructive as larvae . . . the reviewer would like to emphasize that many of the commonest and worst are rarely seen as adults) and the methods and techniques of larval collecting, preservation and study. Five keys to nymphs, larvae, pupae and puparia, along with 14 plates illustrative of critical characters and forms, provide means for identification to orders of Nearctic insects.

The larvae of Lepidoptera are introduced with a discussion of characters found valuable in identification and a chart compares the Fracker, Forbes, and Heinrich systems of chaetotaxy. A valuable list of family names indicates interrelationships and degree of acceptance by workers in the field; important families are briefly described and principal species are listed (and most are also figured). The ease and certainty of identification possible with the excellent key and 58 plates will delight those who have used the previously available general keys.

The Hymenoptera are not so completely covered, but on the other hand, neither is the field so complicated, for Dr. Peterson has limited his study to the phytophagous forms. A discussion, a key, and 12 plates are quite adequate to the task the author set himself although it could be wished he had gone much further into the order.

The keys in this volume have been student-tested in the author's classrooms, a technique this reviewer would admire to see more widely adopted as it irons out the principal kinks and tends to eliminate the spots where the specialist-author presumes you know as much as he and hardly need a key anyway. Each section contains a selected, though

extended bibliography to important collateral studies. A glossary and host index in addition to the regular index are an unexpected bonus to an already outstanding volume.

Passing to mechanical matters, the book is lithoprinted which, of course, places a premium on illustration and as the author admits he is very visual-minded anyway, this is all to the good in such a volume. The format and printing are clear and pleasing within the limitations of lithoprint. Keys and plates (called figures by the author, but each contains numerous figures) are numbered with key letter designations. This may be confusing to some, and does make it slightly more difficult to immediately locate a plate from an index reference, but in the face of such all-over excellence, all criticisms are of a very minor nature.—ROBERT W. L. POTTS, Calif. Dept. Agriculture, Bureau of Plant Quarantine, San Francisco 5.

REVIEW OF THE LABYRINTHODONTIA. By Alfred Sherwood Romer. Bull. of the Museum of Comparative Zoology, Harvard College, Vol. 99, No. 1, pp. 1-368. 48 figs. 1947. $4.00, paperbound.

Dr. Romer has reviewed and evaluated carefully the existing knowledge of the Labyrinthodontia. Throughout the monograph the author has been somewhat reserved in propounding changes even though the evidence has been well worked. It is strongly emphasized that the classification and phylogeny are purely provisional in nature and that the work is not intended as a formal systematic revision. Many of the suggestions offered are of some moment and although not presently accepted as a general rule, definitely merit serious consideration.

In the introduction the importance of this group as the basal stock of all tetrapods and as ancestors of the higher vertebrates is pointed out. The former difficulty of the origin of the labyrinthodonts has been resolved by the realization that the Dipnoi and Crossopterygii are closely allied and that *Polypterus* is not a crossopterygian, hence the belief is maintained of a crossopterygian ancestry for the labryrinthodonts. Watson's 1919 publication is cited as the beginning of a reasonable scheme for classification of the group. A short history of labyrinthodont classification is outlined. Following the introduction there is a rather thorough general account of labyrinthodont morphology.

It is Romer's belief that the amphibia may be divided into two major groups with the vertebral centra forming the key to such a dichotomy. One group, the suggested subclass Apsidospondyli, have centra ossified from cartilaginous blocks as intercentral and pleurocentral structures. This group includes the labyrinthodonts and anurans. The other group, subclass Lepospondyli, have no cartilaginous blocks representing centra, formation takes place by direct ossification around the notochordal sheath. This group includes the Urodela and Apoda.

The Labyrinthodontia separated at an early time into the two main categories commonly called the rhachitomes and embolomeres. For these categories the ordinal names Temnospondyli, including all the rhachitomous forms, and Anthracosauria, including the seymouriamorphs as well as all embolomeres, are proposed. The Ichthyostegalia are more closely related to temnospondyls than to anthracosaurs and are included as a suborder in the Temnospondyli. Originally the Ichthyostegalia included only two genera from the late Devonian, but Romer assigns three Carboniferous types to it (*Otocratia, Colosteus, Erpetosaurus*) and states that the early Devonian *Epistostege* may be an ancestral ichthyostegid. Ichthyostegalia then, is an early aberrant side-branch of the rhacitomous stem. All remaining temnospondyls form a single phylogenetic unit. Using the older terms Rhachitomi and Stereospondyli as suborders a new subordinal term, Trematosauria, is added for the Triassic trematosaurs which have an advanced structural condition independent of the other "stereospondylous" types. All primitive members of the Temnospondyli, from the Carboniferous and Permian, have been placed in the suborder Rhachitomi. To attain better definition within the Rhachitomi a series of superfamilies, Loxommoidea, Edopsoidea, Trimerorhachoridea, Microphoioidea, and Eryopsoidea, have been erected. The Trimerorhachoidea is considered a side-branch of Edopsoidea and were mainly larval or neotenous forms. Loxommoidea is regarded as a basal rhachitomous stage and the

genus *Eryops* as the typical rhachitome. Among the eryopsoids are the temnospondyls most highly adapted to a terrestrial existence, but from this point on there is a regression toward a purely aquatic existence.

The trematosaurs of the early Triassic are usually considered as stereospondyls, but they are persistently rhachitomous in vertebral structure. Other features are beyond the level of the rhachitomes; however, it seems these features were acquired in a parallel development to other Triassic families and have arisen independently from Permian rhachitome ancestors. Hence a separate suborder, the Trematosauria, is erected. Romer begins the suborder Stereospondyli with the early neorhachitomes even though they do not possess stereospondylous vertebrae; but this is no more inconsistent than the inclusion of the capitosaurs which have always been considered a major element of the stereospondyls. The more primitive neorhachitomes, mainly from South Africa, with a more generalized skull shape and primitive characters are grouped as the superfamily Rhinesuchoidea, and may include the common ancestors of the later stereospondyls. The Triassic capitosaurs appear to form the termination of the "main line" of temnospondyl evolution. A superfamily Brachyopoidea is set up to receive the two families of plagiosaurs and brachypoids. The superfamily Capitosauroidea is erected for the Triassic capitosaurs and for *Benthosuchus* and its allies from the basal Triassic.

The order Anthracosauria includes the very primitive amphibian types and are related to the ancestry of reptiles; many of the diagnostic characters are reptilian in nature. This order is divided into the suborder Embolomeri, which is the basal stock, and the suborder Seymouriamorpha, which consists of *Seymouria* and its relatives. Seymouriamorpha (late Pennsylvanian to late Permian) arose from the embolomeres as a side-branch near the family Palaeogyrinidae and typical forms are too specialized to be considered the actual ancestors of the primitive cotylosaurian reptiles. *Seymouria* of the American Permian is structurally close to the boundary between Amphibians and reptiles.

It is pointed out that recent evidence suggests the origin of the Anura from primitive rhachitomous temnospondyls in the neighborhood of the superfamily Edopsoidea, possibly in the early Pennsylvanian. Reptiles possibly evolved from near the family Diplovertebrontidae of the Seymouriamorpha in the upper Pennsylvanian.

Parallelism is a prominent but confusing feature in the study of labyrinthodont evolution. This is evidenced in late Carboniferous and early Permian features which are characteristic of the Triassic labyrinthodonts.

The book has been painstakingly prepared. It is interestingly written, the figures are very clear, there are tables showing stratigraphic occurrences of labyrinthodonts from the Devonian through the Triassic, a provisional family tree is included, and the publication is relatively free from typographical errors. The bibliography of 352 titles covers the years between 1847 and 1946 with emphasis on the more important morphological and stratigraphical works.—R. L. LIVEZEY, University of Notre Dame, Notre Dame, Indiana.

ON VENEZUELAN REPTILES AND AMPHIBIANS COLLECTED BY DR. H. G. KUGLER. By Benjamin Shreve. Bull. of the Museum of Comparative Zoology, Harvard College, Vol. 99, No. 5, pp. 517-537. 1947. $.40, paperbound.

This short paper is a report on a series of 47 forms of amphibians and reptiles collected mainly in Falcon state, Venezuela. The series consisted of one turtle, eighteen lizards, nineteen snakes, one caecilian, and eight frogs and toads. Dr. Shreve describes two new subspecies of lizards (*Gonatodes caudiscutatus falconensis* and *Tretioscincus bifasciatus kugleri*), one new subspecies (*Leptodeira rhombifera kugleri*) and one new species (*Oxyrhopus venezuelanus*) of snakes from the collection. Some observations by Kugler of the appearance in life of several of the forms are also included.—R. L. LIVEZEY, University of Notre Dame, Notre Dame, Indiana.

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The American Midland Naturalist

Founded by J. A. Nieuwland, C. S. C.

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FLORA OF ILLINOIS

by

George Neville Jones

Pp. vi+368. Clothbound, postpaid, $4.25.

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